

ASTRONOMY

DECEMBER 1973

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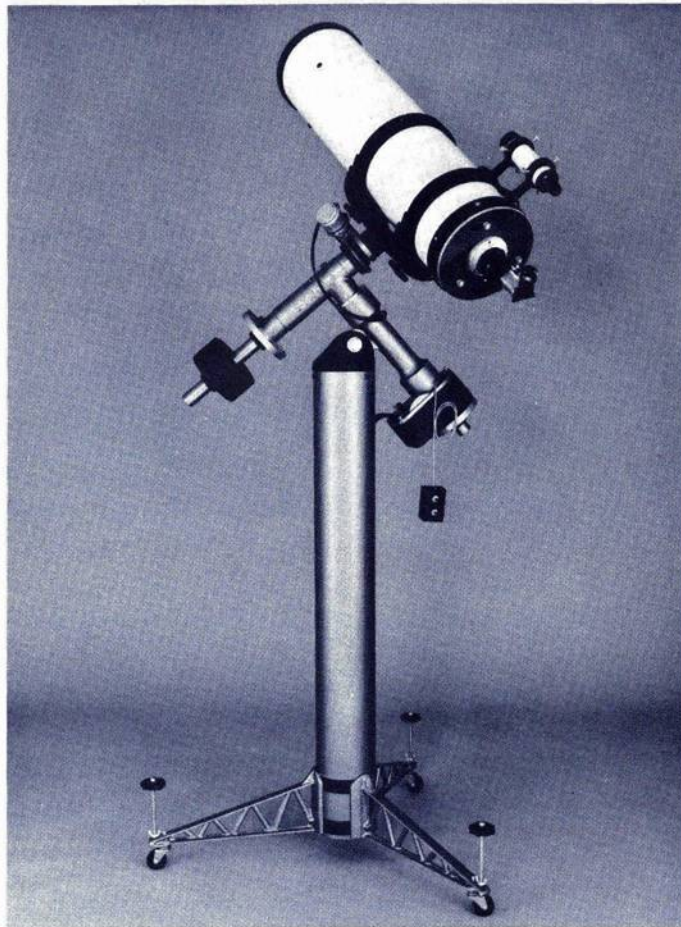
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ASTRONOMY

The World's Most Beautiful Astronomy Magazine

December 1973

Vol. 1, No. 5

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Cover

The magnificent Pleiades is a cluster of several hundred stars, the brightest of which can be seen high in the east these winter evenings. The brightest stars are embedded in dust and gas that becomes illuminated in the same way that bright streetlamps impart a glow to hazy air around them. This reflection nebulosity, as it is called, is only well seen in long exposure photographs. But the cluster itself deserves attention as described in Sky Almanac this month.

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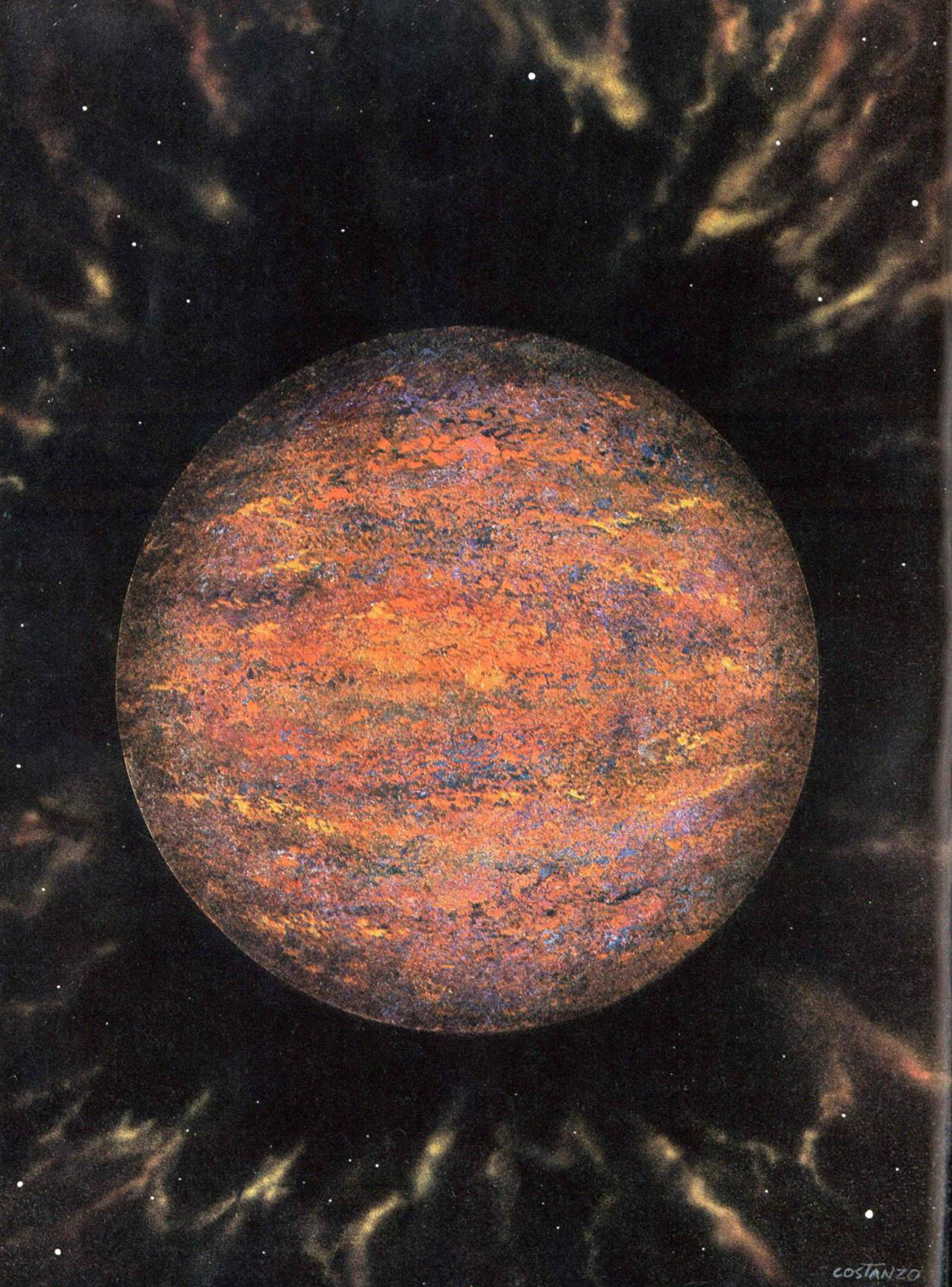
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LIFE ON A NEUTRON STAR

An Interview with Frank Drake

A sphere of matter so dense that every cubic inch weighs a billion tons! Can there be such matter in the universe? Surprisingly, exactly such a form of matter had been hypothesized as long ago as 1939 by Landau in the Soviet Union and Oppenheimer in the United States. But no one at that time actually believed it would ever be observed. Theoretically it would be possible to squeeze all the space out of matter so that the nuclei of the

The surface of a typical 10 mile diameter neutron star (left) is not a seething inferno of gases like the sun. Instead, its solid surface is surprisingly like a planet's. A leading astronomer speculates that this surface could support a life form more bizarre than the wildest speculations of some science fiction writers. In this illustration artist Victor Costanzo visualizes the tiny, incredibly dense globe of a neutron star — an object whose existence has only recently been uncovered.

atoms were touching one another. The problem is, of course, how to do it.

The suggestion was made that if a large star were to collapse on itself, the gravity would be sufficient to hold the nuclei together against their enormous mutual repulsion once the star had reached a diameter of about 10 miles. Landau and Oppenheimer worked out what would happen in such a star with all these nuclei rubbing against one another and they found that through nuclear reactions, almost all the particles would convert themselves into neutrons. And so they called this hypothetical matter neutron star matter. They showed mathematically that it could exist, though no one ever thought that it would be seen. But since 1967, we have been observing it because a pulsar has all the characteristics of a neutron

star and nothing else. (A pulsar is the name given to a neutron star that is rapidly rotating and beaming out regular pulses of energy.)

Dr. Frank Drake, director of Cornell University's 1000 foot Arecibo radio telescope — the world's largest — talked about neutron stars to ASTRONOMY's Terence Dickinson. He spoke of the bizarre nature of these objects and ventured an amazing speculation about life on a neutron star.

First he provided some background information. "If we were to compress Earth to the density of a neutron star," he began, "it would be about 100 yards in diameter. Neutron star matter is totally alien to our experiences. Suppose you had a cubic inch of it in your hand. You let go of it. By the time it reached the floor it would have enough energy to bore a hole all the way through Earth. It would go out the other side and rise six feet off of whatever floor is there and then it would go back down through the hole and oscillate back and forth through Earth for a time no one has ever calculated. By comparison, the matter of which we are made — and our Earth is made — is essentially a high vacuum. It is a vacuum relative to neutron star matter far better than any we can make in our laboratories here on Earth. And yet neutron star matter really exists."

Dr. Drake and other scientists have been studying the nuclear physics that takes place in neutron star matter. They were then able to construct a "model" of a neutron star. They find that the star's interior is almost entirely neutrons with just a small amount of protons and other nuclei. Toward the surface of the neutron star is a region a few miles thick where there are some iron nuclei. The iron nuclei repel one another and arrange themselves in a very regular pattern — a cubic lattice, in the terms of a crystallographer.

This lattice is believed to duplicate the crystalline structure of ordinary table salt. This means the material of a neutron star is acting like a normal solid on Earth, despite the fact that it is an entirely new and different form of matter. Therefore, the exterior of a neutron star is not like a star at all; it is like a planet — like Earth. Earth has a liquid core, like a neutron star, and a solid surface, like a neutron star.

Can we test this theory? "Yes we can," said Drake, "because we would expect the same phenomenon on a neutron star as we see on Earth. If the figure of the object changes, we would expect the crust to crack producing the equivalent of what we call earthquakes. When an object is spinning fast, it's oblate just as Earth is oblate (flattened at the poles). As it spins slower it wants to become more round as the centrifugal force on its equator is reduced and so the shape of the crust

is forced to change. As it does so, we should expect to see a cracking of the crust, a starquake in the case of a neutron star. The star will shrink abruptly. Just as when an ice skater pulls in her arms, the neutron star should spin somewhat faster."

Has this ever happened? At the Arecibo observatory, the most famous pulsar, the Crab Nebula Pulsar, was observed for months and all the time a watch was kept for a sudden speeding up of the pulses (and hence the rotation). Suddenly on September 28, 1969, the pulsar abruptly sped up. It has done this four times since then — always abruptly speeding up. This is exactly what was predicted for the idea that the object has a solid crust and has starquakes! The pulsar period shortened by about a millionth of a millionth of a second on those days. And Dr. Drake and his colleagues have calculated that the crust of the pulsar shrank in diameter about 10 millionths of an inch!

So despite the fact that the Crab Nebula Pulsar is six thousand light-years from us, it has been possible to detect a motion of about 10 millionths of an inch. "Ten millionths of an inch doesn't seem like a very big earthquake," Drake continued, "but in the gravity of a neutron star, that is an enormous event because the gravity is about a trillion times the gravity of Earth. When the surface of a neutron star shrinks 10 millionths of an inch, the amount of energy released is the same as the crust of Earth falling 100 miles!"

If there are starquakes, it means the crust is cracking and sliding over itself — something like the continental drifting that builds mountains on Earth. "Therefore," Dr. Drake concluded, "there ought to be mountains, perhaps even continents on the surface of neutron stars. But these 'mountains' would be no higher than about 1/2 of an inch." (A 1/2 inch mountain on a 10 mile object has about the same ratio one to the other as the mountains of Earth compared to the diameter of Earth.)

"In a very real sense we have here a scaled down version of Earth." He continued the incredible comparison. "This means we should have 1/2 inch mountains on these objects. And that's a great convenience to any space scientists out there because the atmosphere of a neutron star is only about a 1/4 of an inch high. So if you want to go into outer space from a neutron star you don't need a rocket, you just climb to the top of the nearest mountain and you're there. Well now that's a convenience, but it's not as easy as it sounds, because as you climb, you're fighting the intense gravity. If you work it out, the amount of energy

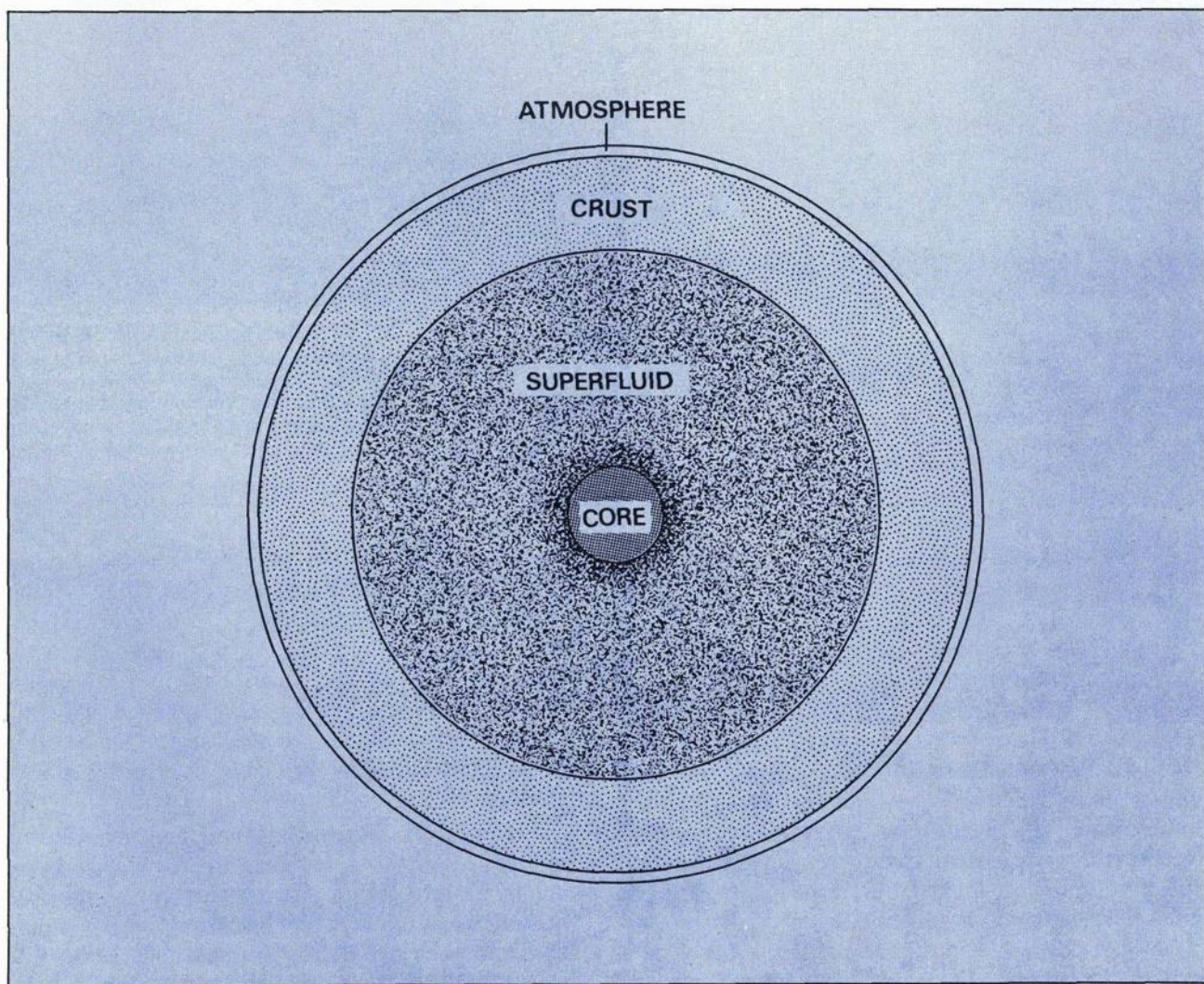
required to climb that 1/2 inch mountain exceeds the total energy your metabolism can produce in a lifetime. So this isn't a job for individual scientists, it's a job for families. They climb up the mountain, passing the torch from father to son and mother to daughter until finally at maybe the fifth generation they get to the top and look out into space."

As incredible as this mountain climbing anecdote sounds, Dr. Drake did not stop there. The gravity and the temperature (100 million degrees) would seem to make the concept of life on a neutron star not worth discussing, but life on these objects may not be impossible. "It may be more reasonable than the life which is filling this room,"

"In the exterior layers of these objects, we don't have atoms," he continued, "but we do have atomic nuclei. And we have more varieties of atomic nuclei in a neutron star than we have var-

ieties of atoms on our Earth. And from what we know of nuclear physics, those nuclei might combine together to form enormous supernuclei, or macronuclei, analogous to the large molecules which make up Earth life. And so as far as we know, it is possibly feasible to reproduce exactly the evolution which occurred on Earth but substituting for atoms and molecules, nuclei and macronuclei. So indeed there could be creatures on neutron stars that are made of nuclei. The temperatures are just right to make the required nuclear reactions go."

The nature of such creatures is as bizarre as the neutron stars themselves. Drake believes they would be so small, a microscope would be required to see them. But they would have all the complexity we do. They could have a brain for example. Yet their life functions proceed at the speed of light, so a lifetime isn't 60 of our years, it's a fraction of a second. Every second of our time would



Artwork by Victor Costanzo

Unlike a normal star, a neutron star has a solid surface of incredible density — so rigid that steel would seem like

water by comparison. It is on this surface that Dr. Drake envisions a possible evolution of complex life forms.



Field Enterprises Educational Corp. Artwork

Rapidly spinning neutron stars are also pulsars because of the unique lighthouse-like flashes of energy they emit. At far left is the neutron star rotating several times per second. In its gravitational grip is an immense magnetic field that also rotates at the same rate. At the outer edge of this field, charged particles are accelerated to the velocity

of light by the tremendous rotation speed. A beam of particles thrown free from the magnetic field form a "hot spot" (right) that is seen from afar as a pulse of light. The energy emitted there also illuminates the surrounding nebula (remnants of the star's outer layers that were ejected in the pulsar's formation).

span several generations on a neutron star. Since the creation of the Crab Nebula Pulsar in the year 1054, there's even been time for an intelligent species to evolve there.

"And for all we know," said Drake, "out there on a neutron star there's a scientist who is the size of a pinhead describing something which is even more bizarre. He may be trying to show that there could be life 'out there' in those places, the ordinary stars, which are very high vacuums to him. It just could be that it is not they who are preposterous, it is we. Because if you were a neutron star scientist and you looked out into space with a good telescope, you might find some very strange objects which are almost completely a high vacuum and near absolute zero by your standards. Temperatures of a few thousand degrees by earthly standards are about a thousandth of a degree above absolute zero by neutron star standards."

The comparison continued as Dr. Drake pictured a famous neutron star scientist saying, "Our theoreticians have predicted things called atoms ... almost empty space ... we never thought they could exist but they seem to exist out there. Could there be life? Suppose those things bond together to make a big molecule? Well it wouldn't be alive. After all, the temperature is too low and everything happens so slowly that nothing ever changes."

Frank Drake's fertile mind has not yet run dry. He said that if such life exists and has achieved interstellar travel they may be navigating through Earth right now! They would think they were passing through a vacuum. And as they passed through at the speed of light nothing would change. To them, we would be indistinguishable from rocks, and life here would be preposterous. 

THE 1974 ORION CALNDAR

New From ASTRONOMY

1974 is just around the corner. And to celebrate its arrival we designed a large, magnificent calendar wall poster.

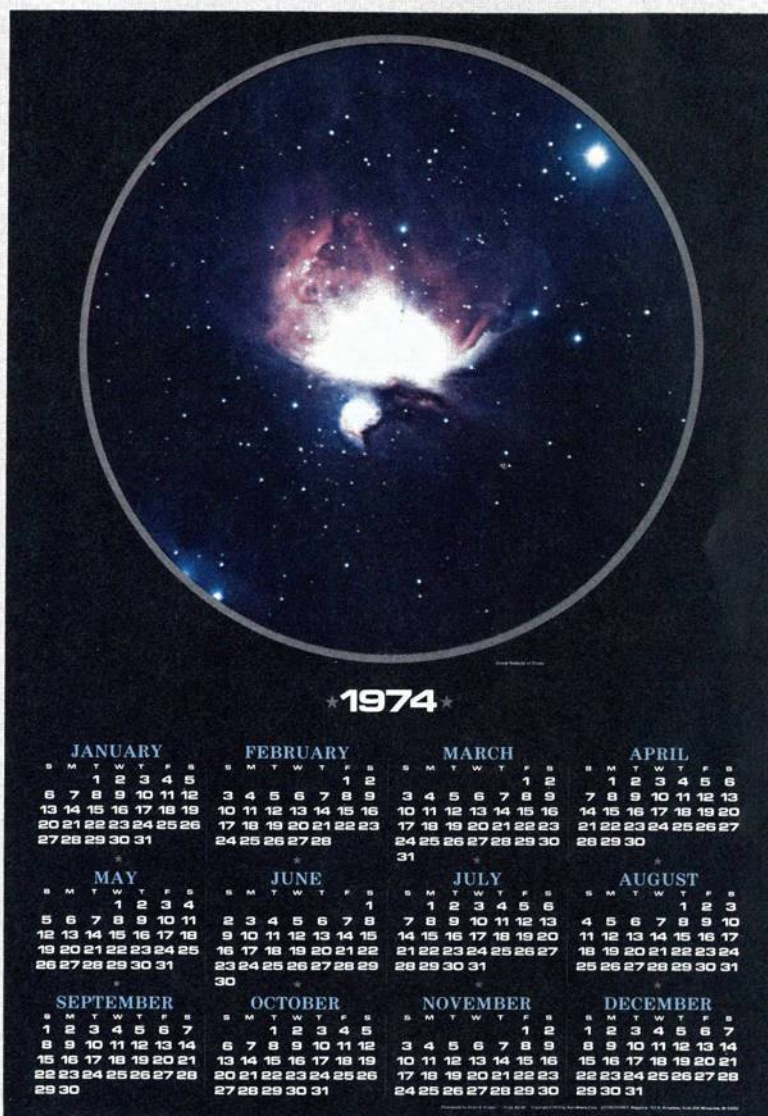
This huge, colorful poster, 22 x 34 inches in size, shows a breathtaking blowup view of the Great Nebula in Orion. Photographed by one of the country's leading freelance astrophotographers, Orien A. Ernest, this detailed blowup exhibits all the colorful splendor that exists in astronomy.

Frankly, we feel the photograph rivals the one made with the 200 inch Palomar telescope.

The intense reds and blues — the dark rifts of dust in this beautiful emission nebula will excite and amaze you as you reflect on the fact that new stars are forming there. A billion years from now, as our descendants gaze toward Orion, they may see a beautiful cluster of stars like the Pleiades.

The Orion Calendar would grace any wall, whether bedroom, classroom, study or office. And it would make an excellent gift for anyone — for the casual enthusiast, student or serious amateur.

This lithographed reproduction is printed on heavy, 8 pt. poster board. And the quality is uncompromisingly excellent! To insure that the Orion Calendar reaches you in A-1 condition it will be rolled — NOT FOLDED — and shipped to you in a mailing tube.



Actual Size: 22" x 34"

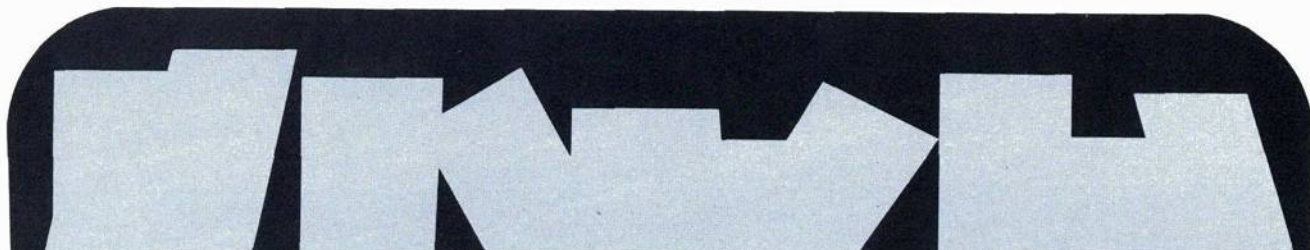
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What an excellent Christmas gift!

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LETTERS TO THE EDITOR

Sir / I would like to report some early observations of Comet Kohoutek. I had been hunting for it unsuccessfully just before morning twilight since late September, but finally found it on the morning of October 23 at about 5:30 a.m. CST. It was located about two degrees south and one half degree west of Phi Leonis and was very difficult to spot in a six inch richest field telescope. Because of its low altitude, and some interference from the waning crescent moon, I found it difficult to estimate its magnitude. It appeared fainter, however, than both M-65 and M-66 (10th and 9th magnitudes, respectively) which I viewed about 10 degrees higher in the eastern sky. Needless to say, the comet was featureless — just a small, faint, fuzzy spot, barely visible without the use of averted vision.

The above sighting was confirmed the following morning when I again spotted the comet a bit further to the east, about two degrees directly south of Phi. On that morning the comet appeared somewhat brighter and was not at all difficult to see, once located. Nevertheless, it was still not as prominent as M-65 or M-66. I also noticed that it was no longer a uniform fuzzy spot, but rather appeared as a star with a hazy glow around it.

I would be most interested in any reports you may have received from other amateurs, particularly in view of the fact that the comet's magnitude seems to be less than predicted.

THOMAS C. BRETL
Oconomowoc, Wis.

Sir / I just recently subscribed to ASTRONOMY and I received the October issue Sept. 25, 1973. So far, with the issues I have received, I have been quite intrigued by the articles that have appeared in your magazine. However, I am somewhat mystified by the "Publisher's Memo" on page 46 of the October issue. You state that if we look closely at the wrapper, we will see that you indicate when it was mailed. I am enclosing the wrapper from my copy of the October issue and there is no indication as to when it was mailed. Being a small town Postmaster, I was not very pleased with your reference to the Post

Office, especially when you refer to date of mailing and that does not appear on the wrapper. I am not condoning the slowness of the Postal Service, however, I am sure you must realize that this is very misleading, since one apparently has to assume that you mailed them by the 20th of the month. Give us a fair shake.

RICHARD A. MAHIN, Postmaster,
Dawson, N.D.

Mr. Mahin / The printer delivered our magazine three days late. We had planned to mail the magazine on Sept. 17, and had type set indicating this fact on the magazine wrapper. Since the printer gave us no certain indication as to when the magazine would be ready to be mailed, we were unable to have new type set. ASTRONOMY was mailed on Sept. 20 but unfortunately we were unable to get new type in time to indicate this fact on the wrapper. While we realize the publisher's memo indicated we would state the mailing date, it was impossible to do so for the October issue and still get the magazine to you on time.

Sir / My August copy of ASTRONOMY arrived almost too late to be of any use.

My September issue was received September 25. Again, too late to be of much use.

The wrapper stated that the September issue was mailed on Aug. 17, 1973.

I called my local postmaster and made my annoyance known in rather strong words. He gave no reasonable explanation for the fact that it took 39 days for the magazine to travel from Milwaukee to Long Island. I am writing to the Postmaster General and the President about this stupid situation. The more the postage costs, the poorer the service.

I must have the October issue pronto, because of the new comet. I am willing to pay first class postage since third class mail is very obviously ignored by the illiterates in our Post Offices.

(Mrs.) ELIZABETH C. BONSALE
Manhasset, N.Y.

Sir / Thank you very much for your informative letter about the status of my subscription. I must admit that I was beginning to get worried. Since I attend UCLA, I have come to know very well how it feels to be "lost in the crowd".

However, your quick and courteous response to my letter shows that you do care about the members of your clientele. This is a very encouraging sign for me in this often discouraging world. I look forward to enjoying your magazine in the coming year.

ED TOOMEY

Sherman Oaks, Calif.

Mr. Toomey / Thank you for taking the time to write. We do receive a barrage of mail at ASTRONOMY and try to answer individually as much of it as possible. We will continue to try to improve our service.

Sir / I find your magazine very informative and worthwhile.

A small section on discoveries or explorations by NASA or others without omitting any of your other regular articles would be of interest.

DEBORAH CARDEN

Walnut Creek, Calif.

Ms. Carden / We hope Astro-News suffices. Thank you for your suggestion.

Sir / I have glanced over the first issue of ASTRONOMY. I am very pleased and happy to say it will have a very long life in the world of astronomical literature. The photographs and articles such as Constellation Close-Up are very enjoyable.

I personally believe that the magazine should have several more pages and a few more advertisements. It may seem strange to say that a magazine does not have enough ads but in ASTRONOMY, one needs to know more about equipment for sale. Good luck!

MARK FLETCHER

Canton, Ohio

Mr. Fletcher / As you can see, we have increased the size of ASTRONOMY by 16 pages, and have additional advertisements, including our new Astro-Mart section.

Sir / My compliments to ASTRONOMY for the superb article on Comet Kohoutek (October 1973 issue). I am waiting with the rest of the astronomical world for its outcome.

Keep up the good work on America's best ASTRONOMY magazine.

JAMES KUPER

Aviston, Ill.

Sir / After three issues of ASTRONOMY, I consider your magazine a success.

The art of Victor Costanzo is beautiful and enriches the whole issue.

I also enjoyed Dr. Carl Sagan's article on "The Hurtling Moons of BARSOOM". I hope such art and articles will continue in future issues.

MICHAEL E. THOMPSON

Brooklyn, N.Y.

Sir / I just wanted to write a few words to tell you and your staff how much I enjoyed ASTRONOMY magazine. I think it is very beautiful, well illustrated and very informative.

I am beginning my first year of college and hope someday to be a professional astronomer. I look forward to many years of enjoyment from this new magazine. Thank you for sending the letter asking me to subscribe.

GARY DAVIS

Wesson, Miss.

Mr. Davis / Much luck in your career from the staff of ASTRONOMY.

Sir / A quick note about your magazine ASTRONOMY. I think it is great, and could become a vast source of information for everyone interested in astronomy.

I think a lot of the younger people are becoming interested at about high school age, as compared to 30 or 40 years ago. Over half of my 72 grandchildren are interested and are anxious to learn more.

So I suggest you try to contact all the high schools in the country as possible subscribers to ASTRONOMY.

E. H. ROUSSEY

Kingston, Wash.

Mr. Roussey / Thank you for your suggestion.

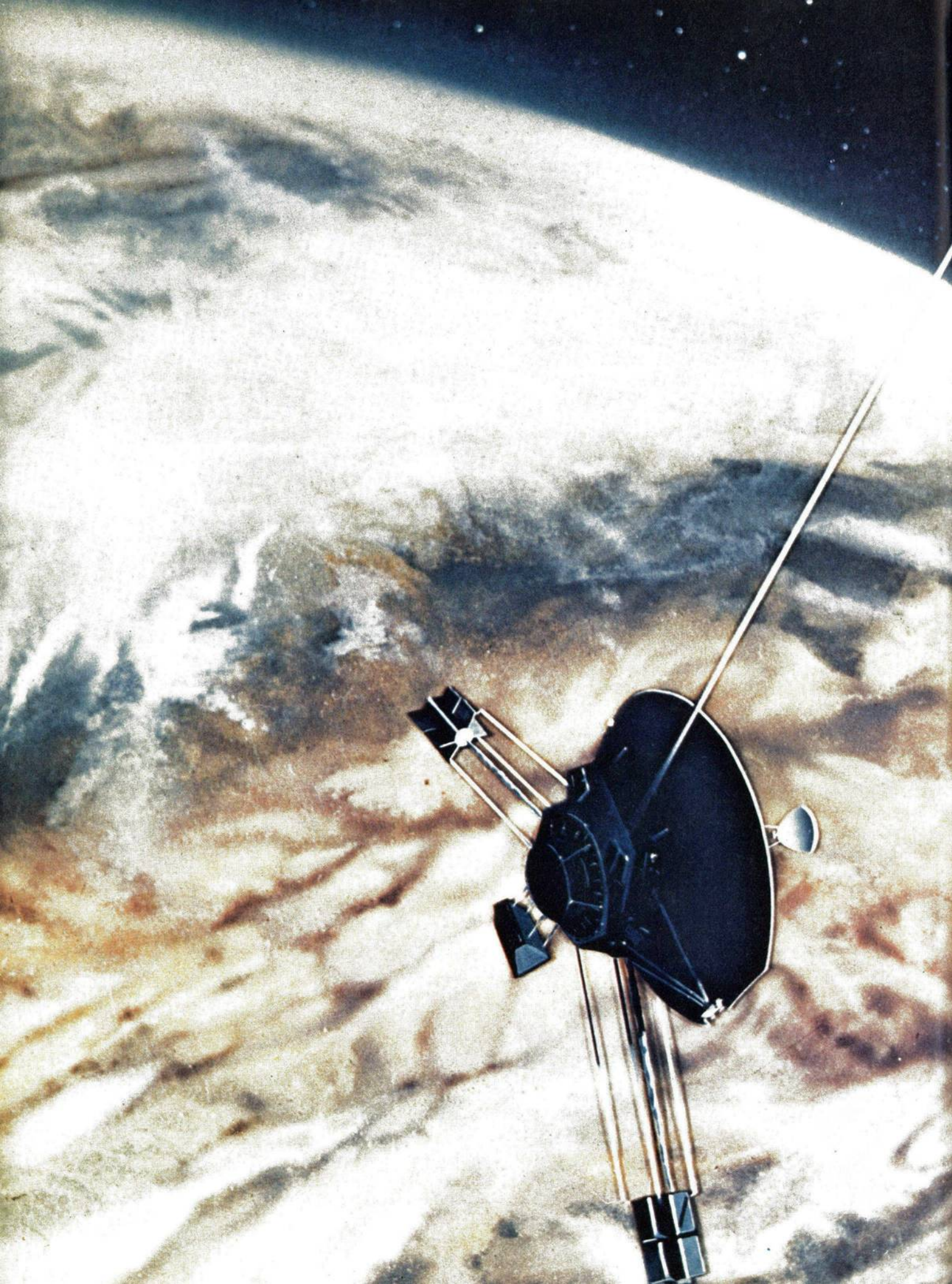
Sir / ASTRONOMY is the magazine I have long been waiting for. I consider myself an amateur astronomer and have read everything available on the subject. Trouble was, though, there wasn't much available.

I have found Sky Almanac very useful in my observations. It pinpointed some objects whose exact position was not known to me. I hope this will be a monthly feature.

Thank you for making this fine magazine available to me.

CHARLES E. EDWARDS

Portage, Penn.



A MESSAGE FROM EARTH

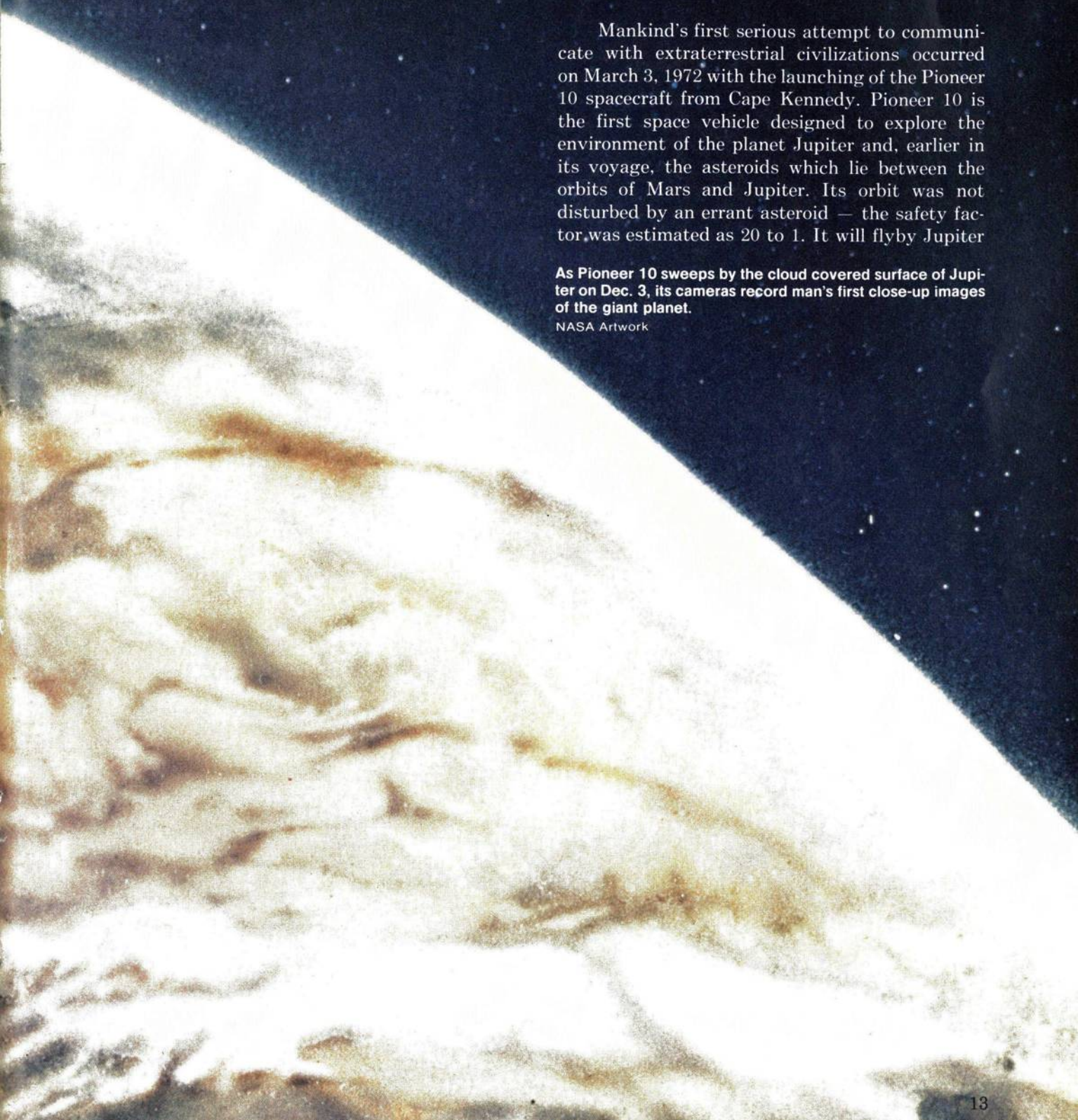
by
Carl Sagan

This article is an excerpt from Dr. Carl Sagan's recent book, **The Cosmic Connection: An extraterrestrial Perspective**. Copyright © 1973 by Carl Sagan and Jerome Agel, published by Doubleday & Company, Inc.

Mankind's first serious attempt to communicate with extraterrestrial civilizations occurred on March 3, 1972 with the launching of the Pioneer 10 spacecraft from Cape Kennedy. Pioneer 10 is the first space vehicle designed to explore the environment of the planet Jupiter and, earlier in its voyage, the asteroids which lie between the orbits of Mars and Jupiter. Its orbit was not disturbed by an errant asteroid — the safety factor was estimated as 20 to 1. It will flyby Jupiter

As Pioneer 10 sweeps by the cloud covered surface of Jupiter on Dec. 3, its cameras record man's first close-up images of the giant planet.

NASA Artwork



on December 3, 1973, and then will be accelerated by Jupiter's gravity to become the first man made object to leave the solar system. Its exit velocity is about seven miles per second.

Pioneer 10 is the speediest object launched to date by mankind. But space is very empty and the distances between the stars are vast. In the next 10 billion years, Pioneer 10 will not enter the planetary system of any other star, even assuming that all the stars in the galaxy have such planetary systems. The spacecraft will take about 80,000 years merely to travel the distance to the nearest star, about 4.3 light-years away.

But Pioneer 10 is not directed to the vicinity of the nearest star. Instead, it will be travelling toward a point in the celestial sphere near the boundary of the constellations Taurus and Orion, where there are no nearby objects.

It is conceivable that the spacecraft will be encountered by an extraterrestrial civilization only if such a civilization has an extensive capability for interstellar spaceflight and is able to intercept and recover such silent space derelicts. There may, for all we know, be civilizations immensely more advanced than our own, which have such capabilities.

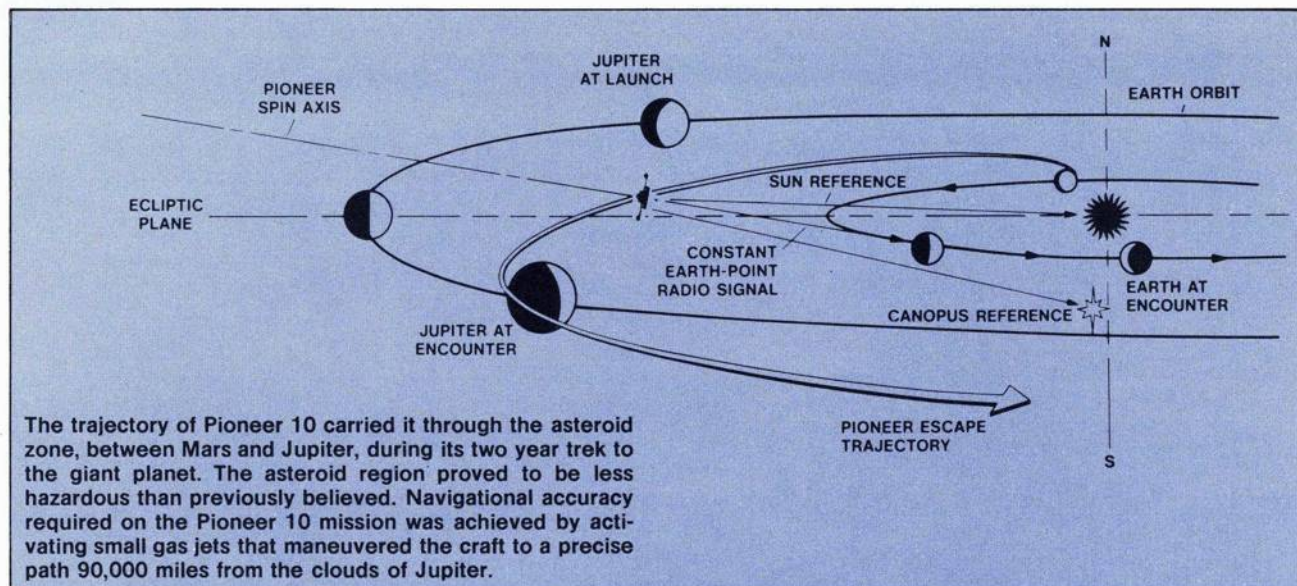
Placing a message aboard Pioneer 10 is very much like a shipwrecked sailor casting a bottled message into the ocean — but the ocean of space is much vaster than any ocean on Earth.

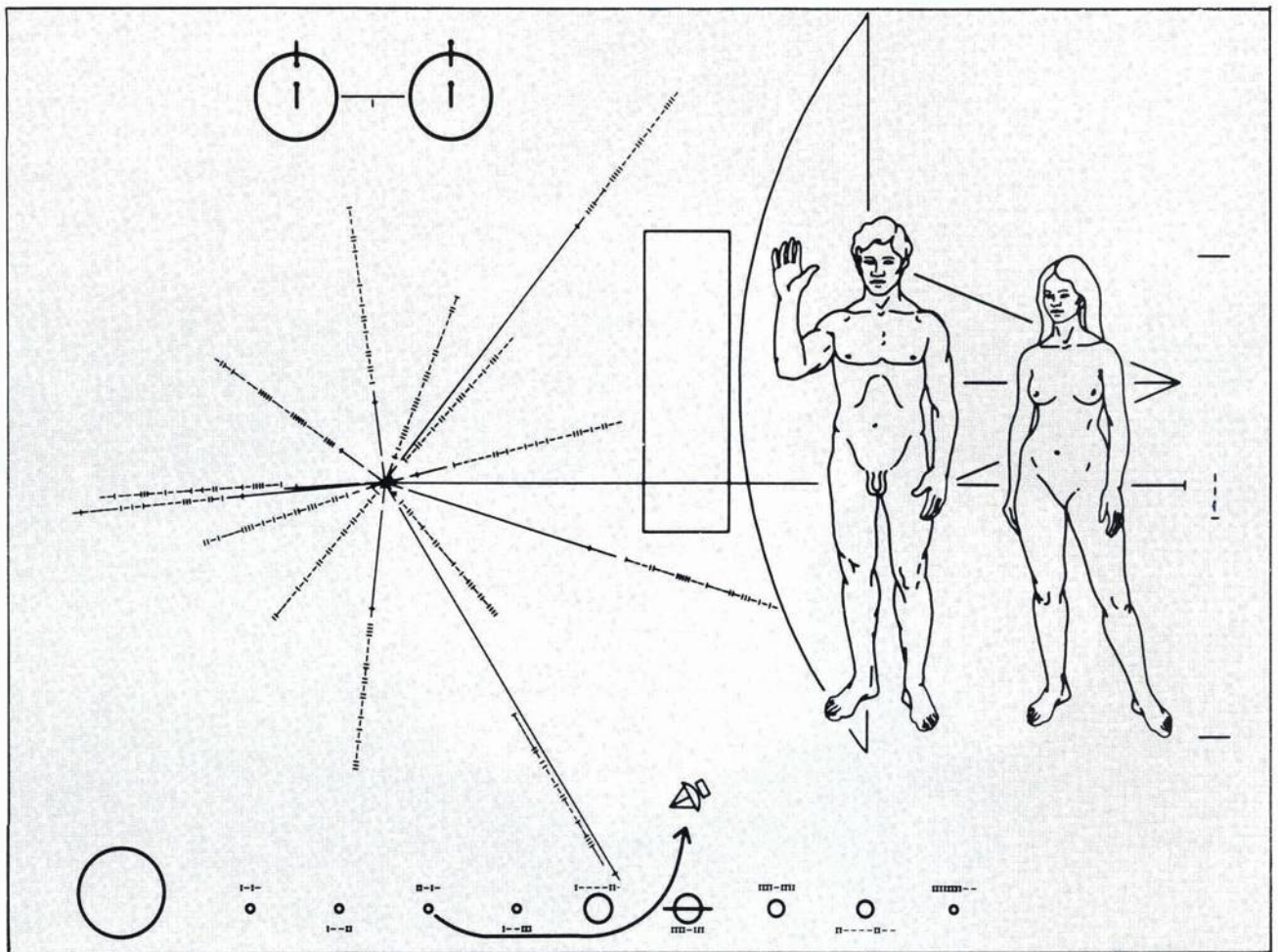
When I had my attention drawn to this possibility of placing a message in a space age bottle, I contacted the Pioneer 10 project office and the National Aeronautics and Space Administration headquarters to see if there was any likelihood of implementing this suggestion. To

my surprise and delight the idea met with approval at all steps of the NASA hierarchy, despite the fact that it was — by ordinary standards — very late to make even tiny changes in the spacecraft. During a meeting of the American Astronomical Society in San Juan, Puerto Rico in December 1971, I discussed privately various possible messages with my colleague Prof. Frank Drake, also of Cornell University. In a few hours we decided tentatively on the contents of the message. The human figures were added by my artist wife, Linda Salzman Sagan. We do not think it is the optimum conceivable message for such a purpose: there were a total of only three weeks for the presentation of the idea, the design of the message, its approval by NASA, and the engraving of the final plaque. An identical plaque is also on the Pioneer 11 spacecraft, launched earlier this year on a similar mission.

The message, shown on page 15 is etched on a 6 x 9 inch gold anodized aluminum plate, attached to the antenna support struts of Pioneer 10. The expected erosion rate in interstellar space is sufficiently small that this message should remain intact for hundreds of millions of years, and probably for much longer periods of time. It is, thus, the artifact of mankind with the longest expected lifetime.

The message itself intends to communicate the locale, epoch and something of the nature of the builders of the spacecraft. It is written in the only language we share with the recipients — science. At top left is a schematic representation of the hyperfine transition between parallel and anti-parallel proton and electron spins of the neutral hydrogen atom. Beneath this representation is the binary number 1. Such transitions of





NASA Artwork

Since Pioneer 10 will be ejected from the solar system, there is a remote but fascinating possibility it will be discovered by other intelligent beings. This is the message

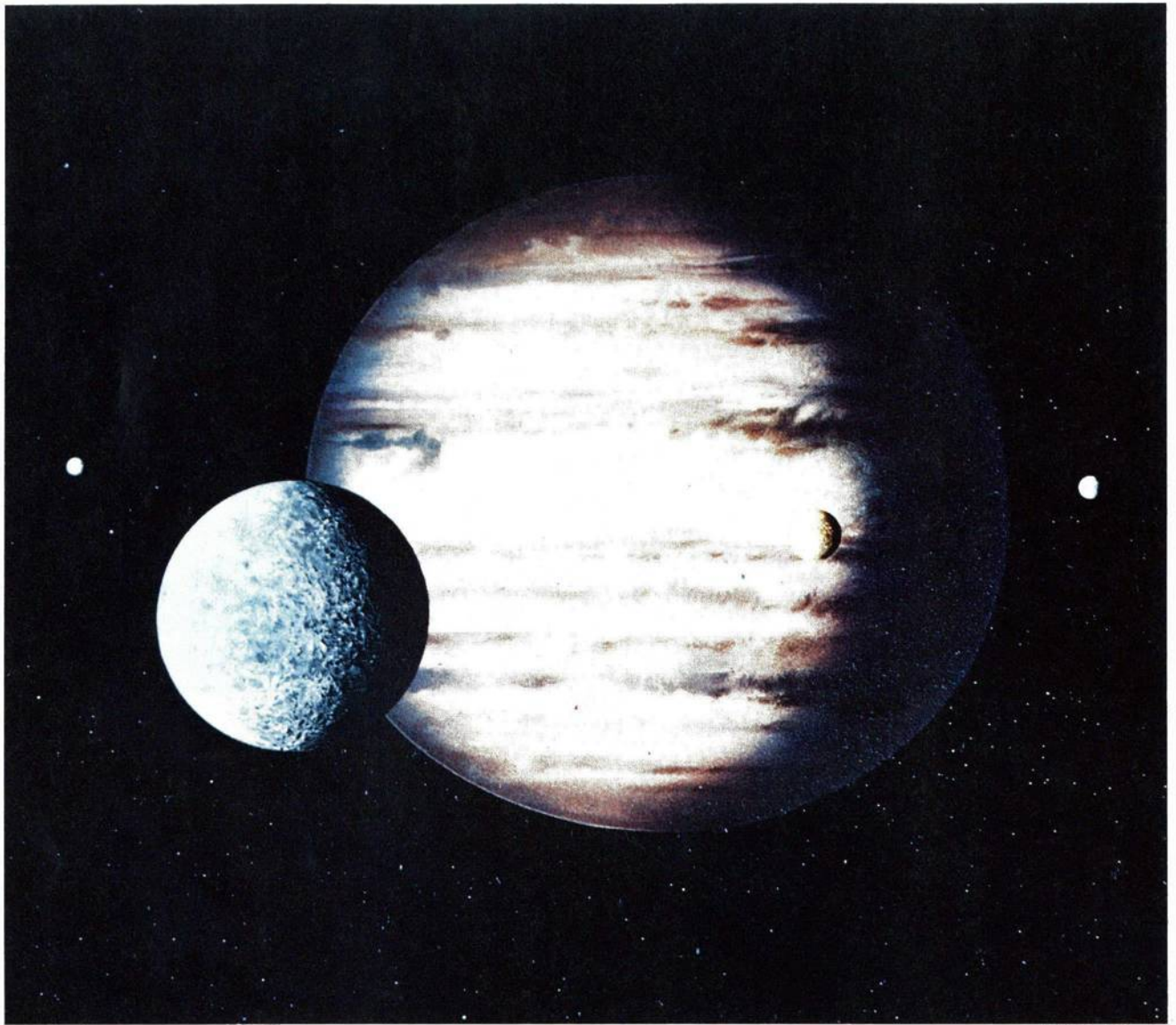
that Pioneer 10 carries. It contains sufficient information for the aliens to determine what Pioneer was, who sent it, and when and where it was launched.

hydrogen are accompanied by the emission of a radio-frequency photon of wavelength about 21 centimeters and frequency of about 1420 Megahertz. Thus, there is a characteristic distance and a characteristic time associated with the transition. Since hydrogen is the most abundant atom in the galaxy, and physics is the same throughout the galaxy, we think there will be no difficulty for an advanced civilization to understand this part of the message. But as a check, on the right margin is the binary number 8 (1---) between two tote marks, indicating the height of the Pioneer 10 spacecraft, schematically represented behind the man and the woman. A civilization that acquires the plaque will, of course, also acquire the spacecraft, and will be able to determine that the distance indicated is indeed close to 8×21 centimeters, thus confirming that the symbol at top left represents the hydrogen hyperfine transition.

Further binary numbers are shown in the

radial pattern comprising the main part of the diagram at left center. These numbers, if written in decimal notation, would be 10 digits long. They must represent either distances or times. If distances, they are on the order of several times 10^{11} centimeters, or a few dozen times the distance between Earth and the moon. It is highly unlikely that we would consider them useful to communicate. Because of the motion of objects within the solar system, such distances vary in continuous and complex ways.

However, the corresponding times are on the order of $1/10$ to 1 second. These are the characteristic periods of the pulsars, natural and regular sources of cosmic radio emission; pulsars are rapidly rotating neutron stars produced in catastrophic stellar explosions (see "Life on a Neutron Star" page 4). We believe that a scientifically sophisticated civilization will have no difficulty understanding the radial burst pattern as the positions and periods of 14 pulsars with



NASA Artwork

The four large moons of Jupiter present fascinating targets for future robot space vehicles. Two of these mini-worlds are about the size of our moon and two are even larger —

similar in dimensions to Mercury, the smallest planet. Recent studies have indicated that at least two of them are substantially covered with frost or snow.

respect to the solar system of launch.

But pulsars are cosmic clocks which are running down at largely known rates. The recipients of the message must ask themselves not only where it was ever possible to see 14 pulsars arrayed in such a relative position, but also when it was possible to see them. The answers are: only from a very small volume of the Milky Way galaxy and in a single year in the history of the galaxy. Within that small volume there are perhaps a thousand stars; only one is anticipated to have the array of planets with relative distances as indicated at the bottom of the diagram. The rough sizes of the planets and the rings of Saturn are also schematically shown. A schematic representation of the initial trajectory of the spacecraft launched from Earth and passing by Jupiter is also displayed. Thus, the message specifies

one star in about 250 billion and one year (1970) in about 10 billion.

The content of the message to this point should be clear to an advanced extraterrestrial civilization which will, of course, have the entire Pioneer 10 spacecraft to examine as well. The message is probably less clear to the man on the street, if the street is on the planet Earth. (However, scientific communities on Earth have had little difficulty decoding the message). The opposite is the case with the representations of human beings to the right. Extraterrestrial beings, which are the product of 4.5 billion years or more of independent biological evolution, may not at all resemble humans, nor may the perspective and line-drawing conventions be the same there as here. The human beings are the most mysterious part of the message. ☛

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TITLE	1956	ARTIST
1. Moonlight Gambler	Frankie Lane	
2. Walk the Line	Johnny Cash	
3. Blue Suede Shoes	Elvis Presley	
4. Tutti Frutti	Elvis Presley	
5. Born to Be With You	Cordettes	
6. Go Away Little Girl	Sue Lawrence	
7. I'm In Love Again	Fats Domino	
8. Blueberry Hill	Fats Domino	
9. Blue Monday	Fats Domino	
10. Just Walking In The Rain	Johnny Ray	
11. Since I Met You, Baby	Ivory Joe Hunter	
12. Long Tall Sally	Little Richard	
13. Layin' It Strange	Mickey & Sylvia	
14. Why Do Fools Fall In Love?	F. Lyman/Tennants	
15. Canadian Sunset	Andy Williams	
16. The Fool	Samford Clark	

TITLE	1957	ARTIST
1. Diana	Paul Anka	
2. That'll Be the Day	B. Holly/Crickets	
3. Oh, Boy	B. Holly/Crickets	
4. Come, Go With Me	Del Vikings	
5. Whispering Bells	Johnny Mathis	
6. Wonderful Wonderful	Johnny Mathis	
7. The Twelfth of Never	Johnny Mathis	
8. School Day	Chuck Berry	
9. Jamaica Farewell	Harry Belafonte	
10. Banana Boat Song	Harry Belafonte	
11. Bee Bop Baby	Ricky Nelson	
12. Stood Up	Ricky Nelson	
13. Butterfly	Charlie Cracie	
14. Party Doll	Buddy Knox	
15. Kisses Sweeter Than Wine	Jiminy Rodgers	
16. Honey Comb	Jiminy Rodgers	

TITLE	1958	ARTIST
1. Rave On	Buddy Holly	
2. Maybe Baby	B. Holly/Crickets	
3. Book of Love	Monotones	
4. Happy, Happy Birthday, Baby	Tune Weavers	
5. For Your Precious Love	Tommy Roe	
6. Susie Q	Lil Anthony/Imperial	
7. Tears On My Pillow	James	
8. Summertime, Summertime	James	
9. Big Man	Four Tops	
10. Whole Lotta Lovin'	Fats Domino	
11. Sixteen Candles	Crests	
12. Summertime Blues	Claydon Cochran	
13. Johnny Be Good	Chuck Berry	
14. A Lover's Question	Claydon Cochran	
15. To Know Him is to Love Him	Teddy Bears	
16. Lonely Teardrops	Jackie Wilson	

TITLE	1959	ARTIST
1. There Goes My Baby	Drifters	
2. Lonely Boy	Paul Anka	
3. Put Your Head on my Shoulder	Paul Anka	
4. Teenager in Love	Dion	
5. Come Softly To Me	Dion	
6. Mr. Blue	Tommy Roe	
7. The Big Hurt	Tony Fischer	
8. Teen Angel	Mark Dinning	
9. Broken Hearted Melody	Mark Dinning	
10. We Got Love	Bobby Rydell	
11. Tragedy	Thomas Wayne	
12. M.T.A.	Kington Trio	
13. Here Comes Summer	Jerry Keller	
14. Waterlute	Stonewall Jackson	
15. It Doesn't Matter Anymore	B. Holly/Crickets	
16. Heartbeat	B. Holly/Crickets	

TITLE	1960	ARTIST
1. Blue Angel	Roy Orbison	
2. Lonely Teardrops	Dion/Belmonts	
3. Where or When	Dion/Belmonts	
4. This Magic Moment	Drifters	
5. Harlem Nocturn	Viscounts	
6. Paddy Love	Paul Anka	
7. Georgia On My Mind	Ray Charles	
8. Chain Gang	Sam Cooke	
9. Walkin' to New Orleans	Fats Domino	
10. Mule Skinner Blues	Ray Charles	
11. Tell Laura I Love Her	Ray Peterson	
12. Wild One	Bobby Rydell	
13. Calendar Girl	Neil Sedaka	
14. Devil or Angel?	Bobby Vee	
15. Rubber Ball	Bobby Vee	
16. Mr. Cutler	Larry Vene	

TITLE	1961	ARTISTS
1. Running Scared	Roy Orbison	
2. Candy Man	Roy Orbison	
3. Moody River	Pat Boone	
4. Spanish Harlem	Ben E. King	
5. Stand By Me	Ben E. King	
6. Some Kind of Wonderful	Drifters	
7. Twist	Chubby Checker	
8. Cupid	Sam Cooke	
9. The Mountain High	Dick & DeeDee	
10. Tonight	Ferrante & Teicher	
11. Gypsy Woman	Impressions	
12. This Time	Troy Shondell	
13. I've Told You Little Star	Linda Scott	
14. A Hundred Pounds of Clay	Gene McDaniels	
15. Moon River	Henry Mancini	
16. Handprints	Dee Clark	

TITLE	1962	ARTISTS
1. Only Love Can Break a Heart	Gene Pitney	
2. If I Didn't Have a Dime	Gene Pitney	
3. She Cried	Jay & the Americans	
4. When My Little Girl is Smiling	Drifters	
5. Up on the Roof	Drifters	
6. Twisten the Night Away	Sam Cooke	
7. Shout	Joey Dee	
8. Sealed With a Kiss	Brian Hyland	
9. Torture	Kris Janzen	
10. Wolfenstein Mountain	Claude King	
11. Love Letters	Kitty Lester	
12. Let's Dance	Chris Montez	
13. Leah	Roy Orbison	
14. Any Day Now	Chuck Jackson	
15. The Night has a Thousand Eyes	Bobby Vee	
16. Sheila	Tommy Roe	

TITLE	1963	ARTISTS
1. Surfin' USA	Beach Boys	
2. Hey, Baby	Bruce Channel	
3. Let Your Music Play	Drifters	
4. Ruby Baby	Dion	
5. Donna the Prima Donna	Dion	
6. Detroit City	Bobby Bare	
7. Rhythm of the Rain	Candice	
8. Mean Women Blues	Roy Orbison	
9. Twenty Four Hours From Tulsa	Gene Pitney	
10. Man Who Shot Liberty Bells	Gene Pitney	
11. More	Kid Winding	
12. Silver Threads, Golden Needles	Lenny Welch	
13. Since I Fell For You	Peter, Paul, Mary	
14. Pull the Magic Dragon	Peter, Paul, Mary	
15. If I had a Hammer	Peter, Paul, Mary	
16. Blowing in the Wind	Peter, Paul, Mary	

TITLE	1964	ARTISTS
1. California Sun	Rivers	
2. Fun, Fun, Fun	Beach Boys	
3. Needles and Pins	Searchers	
4. Come a Little Bit Closer	Jay Americans	
5. Oh, Pretty Woman	Roy Orbison	
6. Dawn	Four Seasons	
7. Glad All Over	Dave Clark 5	
8. Do You Love Me	Dave Clark 5	
9. She's About a Mover	Sir Douglas Quintet	
10. Whim and Hop	Duffy Springfield	
11. Suspicion	Terry Stafford	
12. Memphis	Johnny Rivers	
13. Don't Let Sun Catch You Cryin'	Gerry Pacemakers	
14. Under the Boardwalk	Drifters	
15. I Believe	Bachelors	
16. House of the Rising Sun	Animals	

TITLE	1965	ARTISTS
1. It Was a Very Good Year	Frank Sinatra	
2. California Girls	Beach Boys	
3. Do You Wanna Dance	Beach Boys	
4. What the World Needs Now	Jackie DeGannon	
5. Mrs. Brown, Lovely Daughter	Herman's Hermits	
6. Baby the Rain Must Fall	Glen Yarbrough	
7. Five O'Clock World	Voogs	
8. You Were On My Mind	We Five	
9. Spanish Eyes	Al Martino	
10. Down in the Boondocks	Billy Joe Royal	
11. Game of Love	Wayne Fontana	
12. You've Got Troubles/I've Got	Fortunes	
13. Keep on Dancin'	Gentles	
14. Ferry Across the Mersey	Gerry Pacemakers	
15. Cara Mia	Jay Americans	
16. Some Enchanted Evening	Jay Americans	

TITLE	1966	ARTISTS
1. These Boots are Made for Walkin'	Nancy Sinatra	
2. Soop John B.	Beach Boys	
3. Bang Bang	Cher	
4. Red Rubber Ball	Cyrille	
5. Cherry Cherry	Neil Diamond	
6. Fought the Law	Bobby Fuller 4	
7. Love's Made a Fool of You	Bob Lind	
8. Elusive Butterfly	Mamas & Papas	
9. I Saw Her Again	Peter & Gordon	
10. Woman	Gerry Pacemakers	
11. Lady Godiva	Peter & Gordon	
12. Where Were You, Needed You	Grass Roots	
13. George Girl	Seekers	
14. I'll Never Find Another You	Seekers	
15. A Place in the Sun	Steve Wonder	
16. Quaternary	The Sandpipers	

TITLE	1967	ARTISTS
1. Baby I Need Your Lovin'	Johnny Rivers	
2. A Whiter Shade of Pale	Procol Harum	
3. Brown Eyed Girl	Scott McKenzie	
4. There's a Kind of Hush	Herman's Hermits	
5. Study in Diagon	John Fred/Playboy Band	
6. To Love Somebody	Bob Seger System	
7. San Francisco Nights	Animals	
8. Kentucky Woman	Neil Diamond	
9. Carrie Anne	Hollies	
10. I'll Never Fall in Love Again	Tom Jones	
11. Jackson	N. Sinatra/L. Hazelwood	
12. Different Drum	Stoney Curtis	
13. Silence is Golden	Tremeloes	
14. Somewhere to Love	Jefferson Airplane	
15. White Rabbit	Jefferson Airplane	

TITLE	1968	ARTISTS
1. Young Girl	G. Puckett/Harris Gap	
2. The Magic Moment	Jay & the Americans	
3. MacArthur Park	Richard Harris	
4. Abraham, Martin & John	Dion	
5. Words	See Cies	
6. The Unicorn	Iron Rivers	
7. The Look of Love	S. Mendes/Brazil 66	
8. Tuesday Afternoon	Moody Blues	
9. Hold Me Tight	Johnny Nash	
10. Simon Says	1910 Fruitgum Co.	
11. Ramblin' Gambler Man	Rock Seger System	
12. Born to be Wild	Steppenwolf	
13. Turn Around, Look at Me	Voogs	
14. My Special Angel	Voogs	
15. Master Jack	4 Jacks & a Jill	
16. She's a Heartbreaker	Gene Pitney	

TITLE	1969	ARTISTS
1. Suspicious Minds	Elvis Presley	
2. In the Ghetto	Elvis Presley	
3. Everybody's Talkin'	Nikolas	
4. Good Morning Starshine	Oliver	
5. Jean	Oliver	
6. The Boxer	Simon & Garfunkel	
7. Games People Play	Joe South	
8. Traces	Classics IV	
9. Lodi	CCR	
10. Suite: Judy Blue Eyes	Crosby/Stillts/Nash	
11. Sweet Caroline	Neil Diamond	
12. Laughing	Gunsu Who	
13. Ruby, Don't Take Love to Town	K. Rogers/1st Edition	
14. Baby, It's You	Smith	
15. Welcome Me Love	Brooklyn Bridge	
16. One	Three Dog Night	

TITLE	1970	ARTISTS
1. Ride Captain Ride	Blue Image	
2. I Don't Matter to Me	Bread	
3. Ticket to Ride	Carpenters	
4. Make Me Smile	Chicago	
5. Knock Three Times	Dawn	
6. Your Song	Elton John	
7. Reflections of My Love	Marmalade	
8. Question	Moody Blues	
9. Big Yellow Taxi	The Neighborhood	
10. Mr. Tambourine Man	Nitty Gritty Dirt Band	
11. Band of Gold	Freddy Payne	
12. Black Magic Women	Santana	
13. Celeste	Three Dog Night	
14. Have You Ever Seen the Rain?	CCR	
15. For the Good Times	Ray Price	
16. Long, Long Time	Linda Ronstadt	

TITLE	1971	ARTISTS
1. American Pie (Full Version)	Don McLean	
2. Superstar	Carpenters	
3. Joy to the World	Three Dog Night	
4. Colour My World	Joan Baez	
5. Night Drow Old Dixie Down	Joan Baez	
6. Stones	Neil Diamond	
7. She's a Lady	Tom Jones	
8. Me and Bobby McGee	Janis Joplin	
9. Mr. Tambourine Man	Lubbo	
10. Brand New Key	Melanie	
11. Without You	Nelson	
12. It's One of Those Nights	Partridge Family	
13. Moon Shadow	Cal Stevens	
14. Gypsies Tramps & Thieves	Cher	
15. I Don't Know How to Love Him	Yvonne Elliman	
16. Superstar (Jewie Christ)	M. Head/Trindades	

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☐ 1959 ☐ 1967

☐ 1960 ☐ 1968

☐ 1961 ☐ 1969

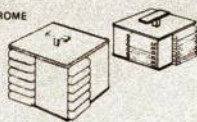
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☐ 1963 ☐ 1971

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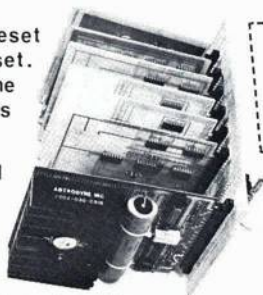
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PHOTOGRAPHY IN ASTRONOMY

Highlight Masking:

A Method of Detail Enhancement

by

Brad D. Wallis and Robert W. Provin

This article is directed to any photographer who wants to capture on film the many beautiful objects he has viewed through his telescope. Whether you have just started taking astrophotos or already have a fair sized collection, you will encounter this classic problem:

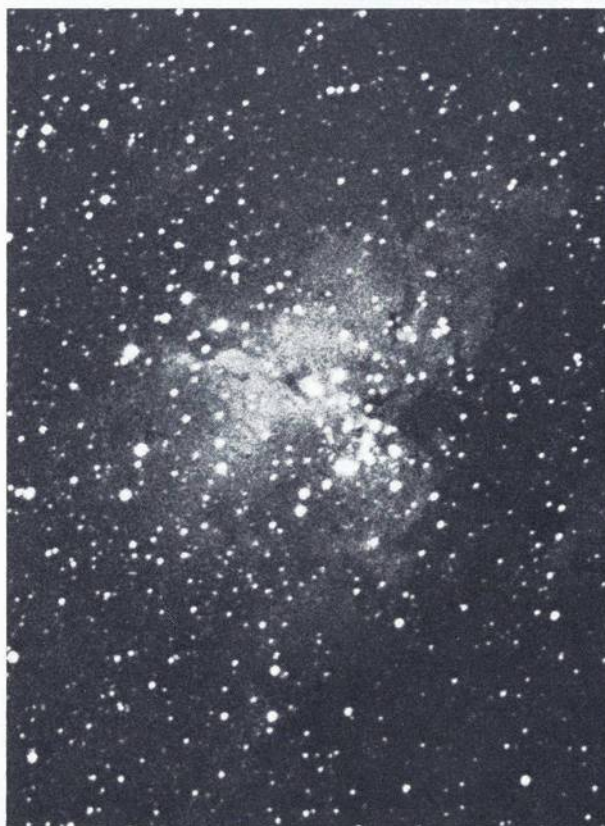
You have just obtained a good quality photograph of M-42. On the negative you can see the wispy outer filaments of the nebula as well as a density change

in the nebulosity just below the area where the trapezium would be located. But when an attempt is made to make a print of this object the results are totally disappointing.

The reason for this problem is that photographic paper cannot capture the range of densities found in most films. What can be done to save this negative? You could make two prints to show



These photographs of M-16 were taken with a 4-1/2 inch f/5.6 reflector telescope. The 30 minute exposure on 103a-E, developed in D-19 for four minutes. The photo at left



was not masked, while the masked print at right shows many dark globules near the center of the nebula, detail around the perimeter of the nebula has been preserved.



The above photographs of M-17 in Sagittarius demonstrate how highlight masking intensifies detail at the center of the nebulae while preserving the thin wisps of nebula at



the perimeter. At left is an unmasked print which shows little or no detail at M-17's center, while the masked photo at right reveals details that can be seen visually.

to your friends: one to show the outer parts of the nebula, and the other to show the inner detail. However, this approach will not satisfy most people as it will not produce a photograph that looks like the observatory photographs that one is used to seeing.

An equally unsatisfactory procedure is to vary exposure time on various parts of the print by "dodging". This technique requires a great deal of practice and patience but will, after many unsuccessful tries, yield one reasonably good print.

Once you have an acceptable print, you might expect that additional prints would be produced with relative ease. This is not the case. Not only do you have to duplicate the exposure times of the printing and dodging periods, but you must also come fairly close to duplicating the motions of the dodging mask used in making the first print. All of this adds up to one fact — dodging, when applied to astronomical objects, does not yield acceptable, consistent results.

There is, however, another more consistent method of varying the exposure given to the various areas of a print. This method is able to produce excellent prints of objects having extreme brightness ranges encountered by astrophotographers. This technique has long been known to professional photographers and is commonly used by custom photographic laboratories today.

The technique is known as "highlight masking", and it involves making the equivalent of a neutral variable density filter to vary the intensity of the light reaching the photographic paper. Fortunately this process is not as difficult as it sounds. All you need is a piece of film and a diffusing surface.

The easiest way to make a diffusing mask is to make a diffused contact transparency of the original negative and then mount the original and the "mask" in register in the enlarger. The image of the original negative is diffused by placing a thin sheet of glass between the two emulsions and

then spinning this emulsion/glass sandwich on a turntable, off-axis, below a light source.

A second method, more easily applied to small format negatives, involves making a sharp, enlarged transparency from the original negative. After this has been processed a sharp contact negative should be made and from this a diffusing mask as described above. The final negative and mask are then sandwiched together in register and prints made. In this method, the two copying steps will always result in the loss of some detail, and unless the choice of copy film is perfect, it will result in a contrast increase.

For the photographs accompanying this article, a third method was used to make a highlight mask. In this method the mask, made on Kodak Professional Copy Film 6125, is the same size as the final print. The advantage here is that registration of the diffused mask with the projected image from the original negative is simplified. The major drawback is that a new high-

light mask must be made for each size print.

Kodak Professional Copy Film 6125 is used for this method because it has a higher contrast index than films normally used to make highlight masks. The copy film tends to subtract out all parts of the image of those areas that are densest on the original negative.

To make the highlight mask, project the original negative through a diffuser consisting of a 1/16 inch thick sheet of glass to which a layer of high quality tracing velum has been attached. Naturally, the 6125 Copy Film under the diffuser should be emulsion side up. To insure proper copy negative density, several separate exposures should be made. The film is then developed in Kodak D-11 for 4-1/2 minutes, fixed, washed and dried.

The highlight mask is then positioned over a sheet of print paper on the enlarging easel and registered with the projected image of the original negative.



Above are photos of the Orion Nebula (M-42) and the northeast portion of the Orion nebula (M-43). At left is an unmasked print taken with a six inch f/4.0 reflector, stopped down to f/5.3 to eliminate the coma. The 20 minute exposure on 103a-F was developed in MWP-2 for 9 minutes. Note

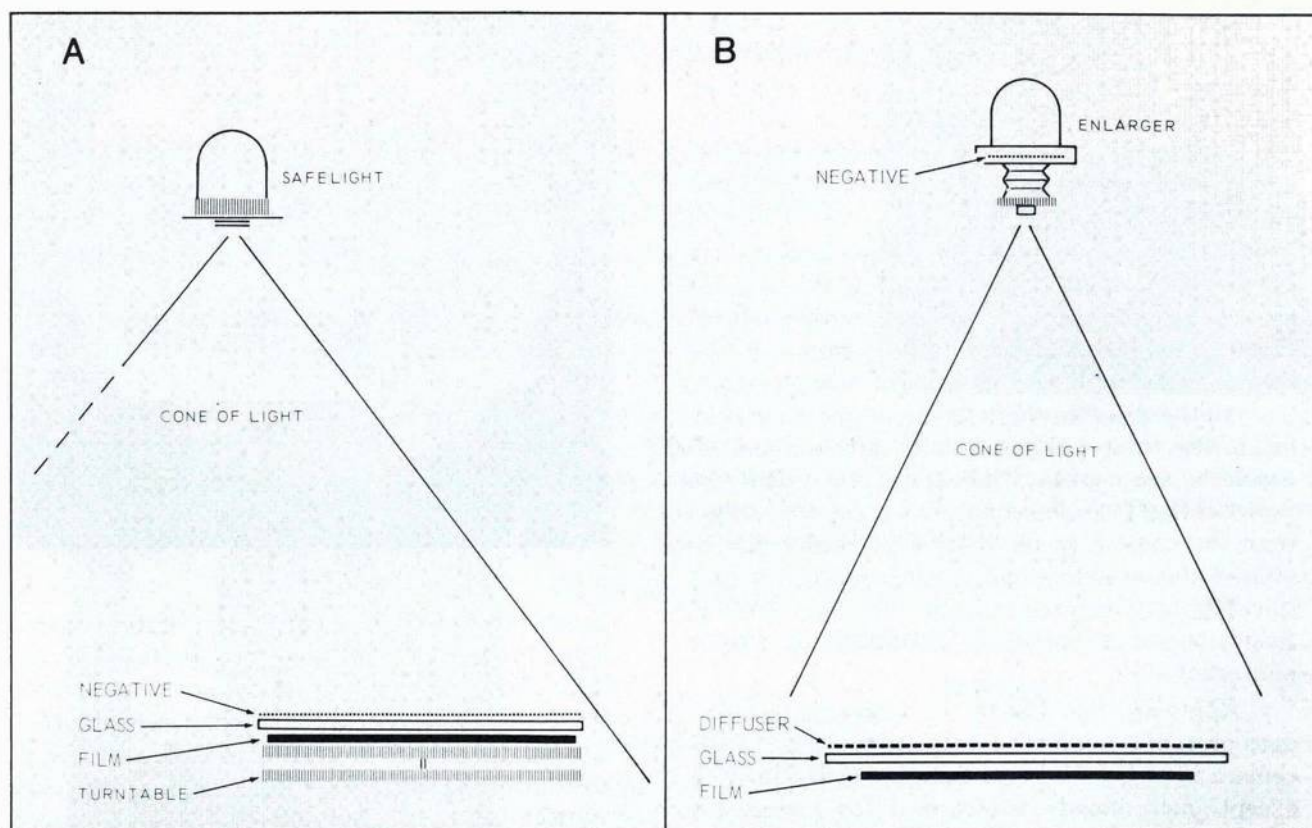


the complete lack of detail in central portions of both nebulae. The masked print right shows all that was on the negative; the outer filamentary nebulosity is well displayed, as are details near the center. The trapezium cannot be seen as it was not on the negative.



The above photograph of M-42 and M-43 in Orion combines the techniques of both highlight masking and integration printing. This photograph was made by integrating three 20 minute exposures of the nebulae while using the masking

technique at the same time. For more information on the techniques of integration printing, see "INTEGRATION PRINTING: An Aid to Long Exposure Astrophotography" in the October issue of ASTRONOMY.



The above diagrams illustrate the methods used to make a diffused copy negative for highlight masking. "A" illustrates the turntable method in which the negative, glass and

film are spun beneath a low intensity safelight. "B" demonstrates the technique used to make a diffused mask the same size as the final print.

Two separate print exposures are necessary to compensate for the detail "subtracting" effect of 6125 Copy Film. The first exposure is made with the highlight mask in place and produces detail in those areas of the print where detail is normally washed out. The second exposure serves to produce the proper background density.

This dual exposure process may have to be repeated several times in order to obtain a well balanced, correctly exposed print. As a result,

it is advisable to record the length of each exposure so you can refer to the best later on.

By using a highlight mask in this way, it is possible to retain high contrast in one area of the print and low contrast in another. This allows you to emphasize low brightness nebulosity, while preserving details in an area where detail is brightest. Once the proper exposure is arrived at and exposure times recorded, you will be able to duplicate your high quality print any time you wish. 🐞

Astrophotography With the Polaroid ED-10

by
Alene D. Oestreicher

When the Polaroid ED-10 Instrument Camera was introduced several years ago, it provided amateur astronomers the opportunity to successfully adapt instant photography to their hobby. The economical ED-10 — a low priced version of high priced professional Polaroid cameras was actually designed for photomicrography, or use with a microscope. The methods and results in

astrophotography described here were obtained strictly on an experimental basis.

The ED-10 is a unique member of the Polaroid family. It contains no lens of its own, and relies exclusively on the optics of the telescope, producing an eyepiece projection system. The focal length of the telescope-camera system in inches can be calculated by multiplying the magnifica-

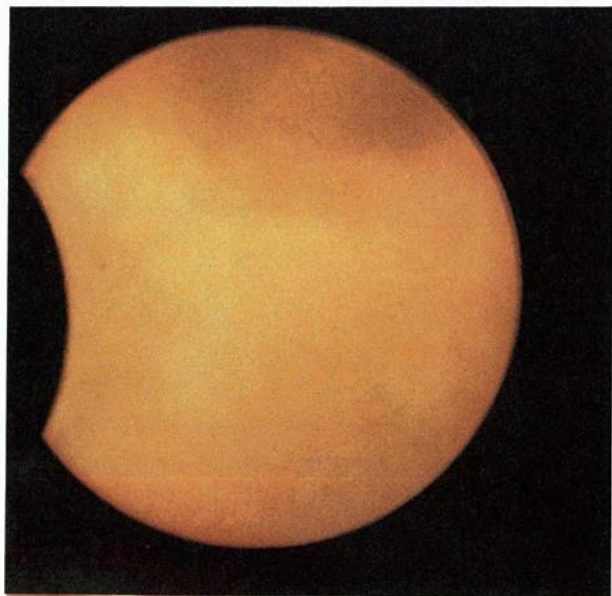
tion of the eyepiece by the quantity eight.

A "focusing tube" is included with the camera to assure a reasonably accurate focus at the film plane. Also a "universal adaptor" allows the camera to be used with almost any type of eyepiece. Exposures are made manually with a cable release, allowing intervals of one second or greater to be timed accurately (exposures below one second require estimation).

Taking a photograph with this camera is a surprisingly simple procedure. First, the adaptor is securely screwed over the telescope eyepiece. The object to be photographed is centered in the field of view, the focusing tube slid over the adaptor, and the object brought to the sharpest possible focus. The tube is then carefully removed and replaced by the camera. The exposure is made, the camera lifted from the adaptor, and the film pulled from the camera to develop. The picture can be viewed almost immediately and mistakes or miscalculations corrected within minutes. This is clearly the most important advantage of instant photography.

Applying the ED-10 to astrophotography does present a number of difficulties, though. The camera is rather long and bulky, and requires an exceptionally steady telescope if the results are to be sharp. Also, the camera's design makes it difficult to mount properly on a conventional camera bracket, favoring a hand-held position. These drawbacks restrict long exposures, and therefore limit subjects to the sun, moon, and planets.

The films available for this model present further advantages and disadvantages. Black and white (type 107) film is super fast at ASA 3000 while color film (type 108) is moderately slow at ASA 75. With black and white film and a low



power eyepiece, filters must be used to reduce light from subjects because exposures shorter than about one-eighth second are not possible. On the other hand, slow color film necessitates a low magnification, or no image will appear at all due to severe underexposure. Color film is also subject to reciprocity failure and subsequent color imbalance. However, the differing characteristics of both films can be used to advantage in the photography of celestial objects. The speed of black and white film is ideal for close-up lunar and planetary photography, while color film records the bright sun and moon almost perfectly within reasonable exposures.

The accompanying photographs were selected from scores of experimental results obtained over the past year and a half, utilizing several different telescopes and various eyepiece combinations. The color pictures of the solar eclipse and full moon were taken with a simple six inch reflector. Two other planets — Mars and Saturn — were also photographed, though they formed much smaller images than giant Jupiter. As a rule, Mars requires a shorter exposure than Jupiter, while Saturn requires a somewhat longer interval. For enhanced planetary detail (and reduced glare), a blue filter should be used with Jupiter and a red filter with Mars. The proper filters and exposures for any telescope-camera setup can be arrived at by taking test photos and evaluating them.

The ED-10 clearly provides astrophotographers an opportunity to expand their horizons by allowing the advantages of instant photography to enter the realm of astronomy.

For more information on the ED-10 Polaroid, write Edmund Scientific Co., 300 Edscorp Bldg., Dept. 12A, Barrington, N.J. 08007. 

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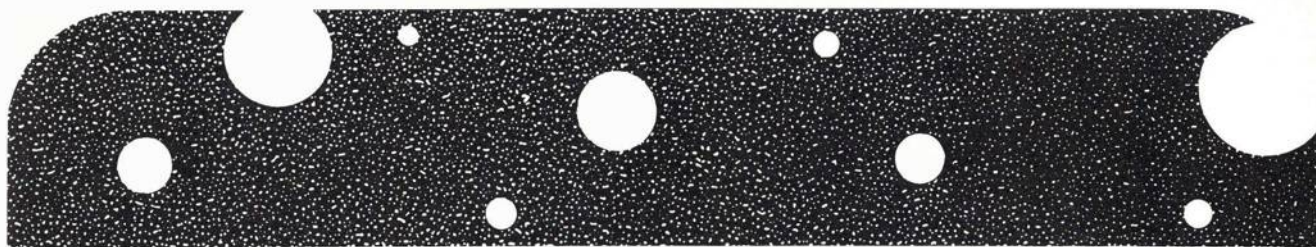


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Inside and Behind the Orion Nebula

by
Gerrit L. Verschuur

To the unaided eye, the middle star in the sword of Orion appears somewhat fuzzy. A small telescope directed to this region reveals a cloudlike patch with a few stars embedded in it. In a larger instrument the cloud's shape is more clearly defined and greenish wisps make it a fascinating sight on a dark moonless night. When Galileo drew this region of the sky in 1609 he either did not notice the nebula or his telescope was too crude to show it.

The first detailed description of the Orion nebula was given by C. Huygens in 1656 although it was recorded earlier by Peirsec (1610) and Cysatus (1618). A century ago, William Huggins determined conclusively that the nebula was a cloud of gas, settling a controversy that had spanned the previous interval.

These earlier explorers of the Orion nebula could not have imagined its magnificent swirling beauty fully revealed only in long exposure photographs. Indeed, during the 20th century the Orion nebula has been one of the most photographed objects in astronomy. It has also proven to be one of the most interesting to astronomers. During recent years a great deal has been learned about conditions within and immediately surrounding this nebula.

The magnificent swirling clouds of the Orion nebula are believed to harbor a birthplace of the stars. Behind the colorful clouds is a denser nebula only recently discovered. The detail captured in this amateur photo rivals that of professional observatories. Orien A. Ernest used high speed Ektachrome for a 25 minute exposure with his 16 inch Newtonian reflector.

The Orion nebula is one of the youngest objects in the sky. If cave dwellers some 25,000 years ago ever plotted the stars of the hunter they would have omitted the central star in the sword. The nebula is believed to have started to shine about 23,000 years ago. So it's a relative newcomer on the celestial scene.

If our sun was 10 times closer to the nebula (140 light-years instead of 1400) it would be the most spectacular object in the sky. It would cover an area equal in size to most of the constellation Orion and have a total magnitude of minus one. But despite its vast distance, new techniques are adding pieces to the Orion nebula story. Even its age is now known. The new findings show that the nebula lies directly in front of a very dense cloud of gas and dust. This dense cloud contains many complex molecules and is believed to be the scene of star formation.

The Orion nebula itself is a hot cloud of incandescent gas called an emission nebula, because it emits its own light and radio signals due to the high temperature of the gas in the cloud. The nebula's temperature of 20,000 degrees Fahrenheit is due to ultraviolet radiation from a group of five hot massive stars called the Trapezium.

Photographs of the Orion nebula show it to consist of two patches — the regions of emission. Radio maps made at many different wavelengths also show this double nature which indicates that hot gases are distributed in these two complexes. Studies of the radio maps have confirmed that the process of emission is the so-called thermal process, due to collisions between electrons in a hot gas.

It is the radio observations of the molecular radiation from the direction of the Orion nebula that turned out to be the most exciting of the recent investigations. The astronomer detects various changes by radio signals in the energy states of molecules as these molecules lose discrete amounts of energy. Conversely, radio signals can be absorbed as the molecules gain energy.

The nebula we can see lies in front of a molecular cloud whose center is lined up just below and behind the Trapezium. The dimensions can even be figured out by the correct interpretation of the enormous funds of data now available on this region. The giant molecular cloud lies one light-year behind the Trapezium. The inner part of this cloud has a diameter of about 1.5 light-years. The cloud extends further than this but its actual outer boundaries have not been accurately determined. The visible nebula is about three light-years deep in our line of sight and about six light-years across, and has a mass equal to 100 suns.

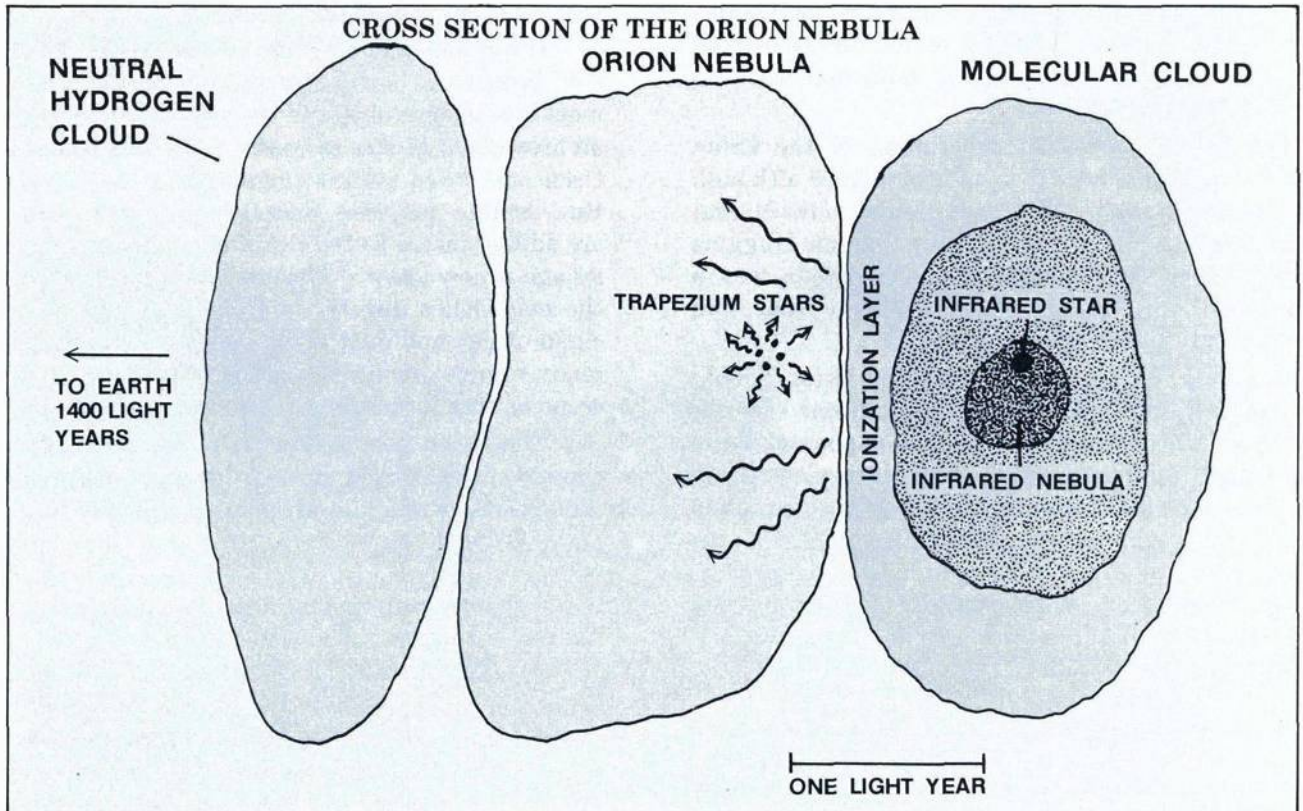
There is relatively little dust in the nebula itself, and what there is appears to have come from the nearby, but hidden, dusty molecular cloud. There is so much dust in the molecular cloud that

it is totally opaque to light.

Within the molecular cloud is a strange infrared object, about four minutes of arc in diameter, called an infrared nebula. Near its center is a tiny infrared star. Neither of these is visible optically and both were found in infrared surveys of the sky made with infrared telescopes. It now seems pretty certain that these two objects indicate the presence of protostars in the molecular cloud. Protostars are those stages in stellar evolution when a contracting cloud of matter has not heated up sufficiently to form a hot, young star. The infrared star has a temperature of about 700 degrees Fahrenheit and its infrared radiation can leak out through the dense dust cloud that surrounds it while its light radiation can not. So it is invisible in optical telescopes.

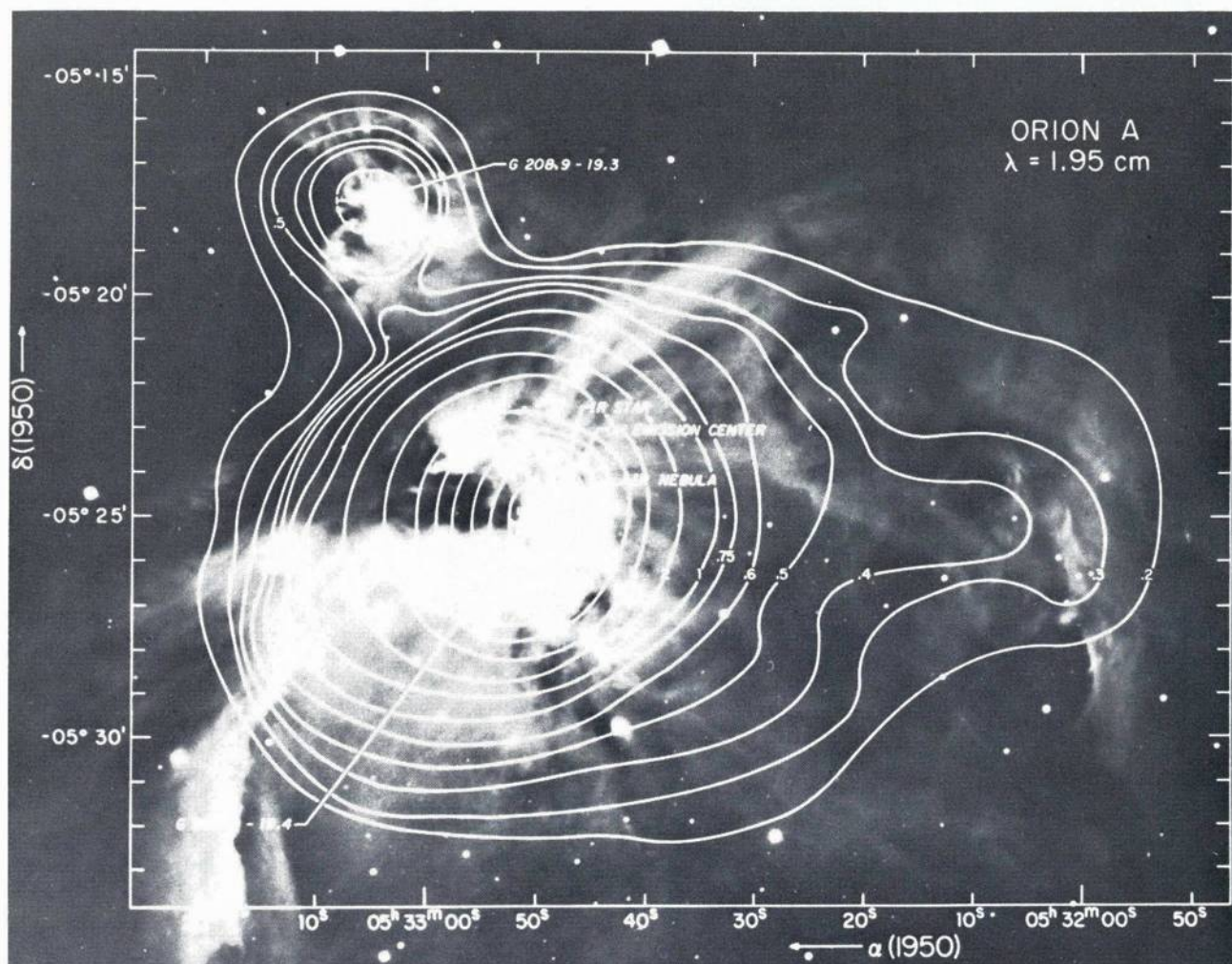
At the position of the infrared star, radio astronomers have found an incredibly small object that emits radio signals characteristic of interstellar water. The diameter of this source is less than 0.003 seconds of arc corresponding to a physical size of only slightly more than the sun-Earth distance.

At least nine other molecules have been found by radio astronomers studying this molecular



If we could view the Orion nebula region from the side, it could be divided into the three basic segments shown here. The visible portion of the nebula conceals a dense

molecular cloud that contains an unusual infrared star. Knowledge of this arrangement has been due to new techniques of radio astronomy.



This radio map of the Orion nebula, called Orion A by radio astronomers, shows the close agreement with the radio contours and the main centers of optical emission. The notation

G 209.0 - 19.4 refers to the radio astronomy nomenclature indicating the galactic longitude and latitude of radio sources. See text for additional details.

cloud. The size of the cloud seems to depend on the species of molecule being studied. This is because the existence of a molecule and its ability to radiate depends on the physical conditions in its vicinity. For example, some molecules occur naturally only inside a dense dust cloud where they are shielded from harmful radiation from outer space, while more stable ones can exist perfectly well in the exposed outer parts of clouds. Maps of the molecular cloud therefore look different depending on which molecule is being studied. Detailed studies of the way molecules are distributed in the Orion cloud give valuable clues about the processes of astro-chemistry.

The study of the motions in the Orion region can be inferred from the Doppler shifts of the Trapezium stars, and by the molecular spectral lines and the recombination lines of hydrogen and carbon atoms. Interpretation of these motions give even more information about conditions in that part of space. It appears that the emission nebula, the one we see in photographs, is approach-

ing us as compared with the stars and the invisible molecular cloud. This is because the ionizing radiation from the stars is virtually boiling off the front side of the molecular cloud. The ionized particles stream away from the molecular cloud into the less dense regions of the Orion nebula itself. Hence they are streaming toward us and give the appearance that the nebula is moving toward us.

We also know that there is at least one relatively dense cloud of neutral hydrogen, somewhat smaller in size than the visible nebula, which lies in front of the nebula. This cloud absorbs the radio signals from the nebula at the hydrogen wavelength of 21cm. It has the distinction of containing the largest magnetic field directly measured in interstellar space.

Next time you look at the sword of the magnificent winter constellation of Orion remember that it contains one of the best studied regions of space and that star formation is even now taking place behind the great nebula. 

AUTHORS

Carl Sagan — Dr. Sagan is director of the Laboratory for Planetary Studies and professor of astronomy and space sciences at Cornell University.

Dr. Sagan's principal research activities are in the physics and chemistry of planetary atmospheres and surfaces, space vehicle exploration of the planets, and the origin of life on Earth. He is also known for his studies in exobiology, the emerging discipline which deals with the possibility of extraterrestrial life and the means for its detection.

Dr. Sagan serves on many advisory groups to the National Academy of Sciences and NASA. He played a major role in obtaining the first close-up photos of the moons of Mars, and in studying surface changes on that planet from the Mariner 9 spacecraft. He was responsible for placing aboard the Pioneer 10 spacecraft the first man-made object to leave the solar system, the first message intended for possible extraterrestrial civilizations.

He was leader of the U.S. delegation to the Conference on Communication with Extraterrestrial Intelligence, organized jointly by the U.S. National Academy of Sciences and the Soviet Academy of Sciences in Armenia in 1971. Vice President of the working group on the moon and planets of the international space organization, COSPAR, and an officer of the planetary commission of the International Astronomical Union, he is also chief editor of ICARUS, the international journal of solar system studies.

In addition to over 150 published scientific articles and papers, and several contributions ("Life", "Mercury", "Venus") to the *Encyclopedia Britannica*, Dr. Sagan has authored, co-authored and edited numerous books on space and planetary research and phenomena, and extraterrestrial life.

Alene D. Oestreicher — A 1973 high school graduate, Ms. Oestreicher has been an amateur astronomer and astrophotographer for several years.

In 1972, she won the Kodak Award at the Baltimore Science Fair for a project entitled "Lunar Photography with a Polaroid Instrument Camera", and also travelled to Canada to photograph the solar eclipse.

During the summer of 1973, Ms. Oestreicher attended an astronomy camp in California, where she used the ED-10 for high magnification lunar and planetary photography.

Brad D. Wallis — A part time staff member of the Griffith Observatory in Los Angeles, Calif., Mr. Wallis has a B.S. in physics and is currently working toward a Master's degree in physical anthropology.

For nearly 10 years, Mr. Wallis has studied and applied various processes used by both amateurs and professionals to obtain better astrophotographs. Among his areas of concentration are instrumentation, photographic theory, hypersensitizing techniques, darkroom techniques (including integration printing and highlight masking), and cooled emulsion techniques.

Mr. Wallis is presently working on a comprehensive book on astrophotography in theory and practice.

John G. Harmon — Mr. Harmon is assistant to the director of the Manfred Olson Planetarium at the University of Wisconsin — Milwaukee, Milwaukee, Wisc. He has worked for the planetarium since 1968 — first as an undergraduate teaching assistant, and now as a Planetarium Specialist.

Mr. Harmon's current projects include the design and building of special effects projectors for the planetarium, and the restoration of a five inch refractor telescope built in 1870 by telescope designer Alvin Clarke.

Thomas C. Bretl — Mr. Bretl is a free lance writer and is doing independent work in astronomy, photography and education.

He received a B.A. in mathematics from Haverford College in 1968 and his M.A. degree in the same field in 1969 from Northwestern University.

Mr. Bretl taught math at Morton Junior College in Cicero, Ill. for one year. In 1970 he went to the University Lake School (which he had attended as a child) in Hartland, Wisc. as a physics and math teacher. There, he again became interested in astronomy. In 1971 he ground and polished an eight inch RFT mirror. Later, aided by some of his students, he constructed a 10 inch telescope.

Mr. Bretl is the current president of Starcraft, Inc., a group of astronomy enthusiasts in Oconomowoc, Wisc.

Robert W. Provin — Mr. Provin is staff cartographer in the geography department at the California State University, Northridge, Calif.

He first became seriously involved in amateur astronomy through the American Association of Variable Star Observers (AAVSO). For the last 10 years, his primary interest has been astrophotography, specifically those techniques that maximize information from small instruments.

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by Alene D. Oestreicher

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DECEMBER STAR DOME

by John G. Harmon

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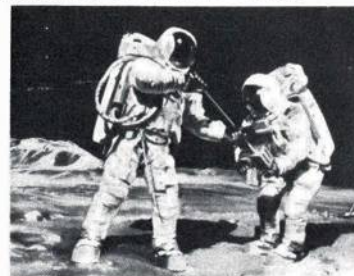
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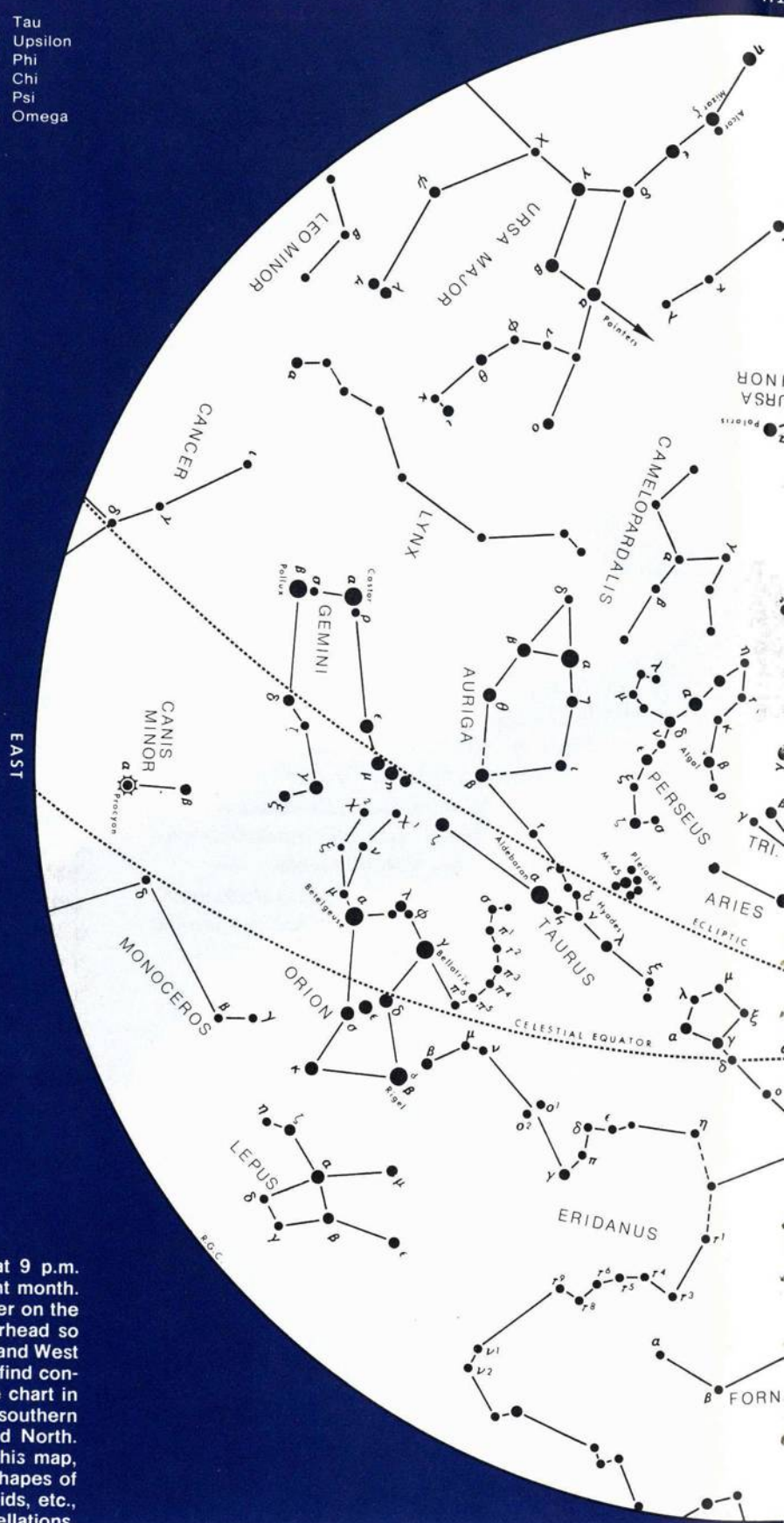
α Alpha	η Eta	ν Nu	τ Tau
β Beta	θ Theta	ξ Xi	υ Upsilon
γ Gamma	ι Iota	$\omicron$ Omicron	ϕ Phi
δ Delta	κ Kappa	π Pi	χ Chi
ϵ Epsilon	λ Lambda	ρ Rho	ψ Psi
ζ Zeta	μ Mu	σ Sigma	ω Omega

MAGNITUDES

- ☉ Zero
- First
- Second
- Third
- Fourth
- Fifth

OBJECTS

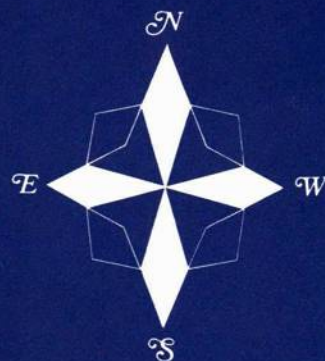
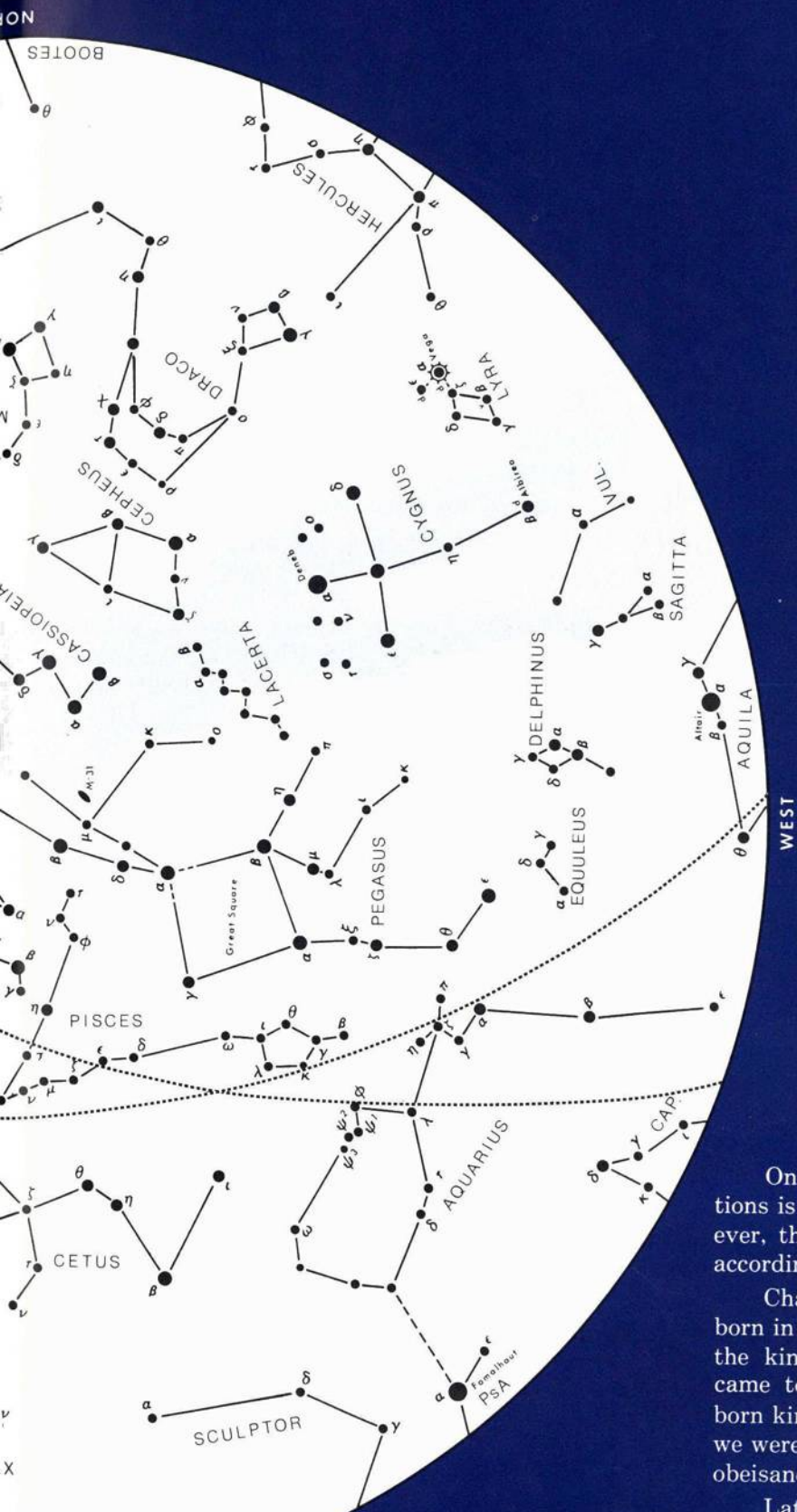
- ★ Open Clusters
- ⊛ Globular Clusters
- Diffuse Nebulae
- ☾ Galaxies
- Double Stars
- Variable Stars



Star Dome approximates the sky as it appears at 9 p.m. Local Standard Time on the first day of the current month. The same constellations are visible one hour earlier on the 15th. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder in Sky Almanac.

Map by Raymond G. Couthie

STAR DOME



by
John G. Harmon

One of the most enduring Christmas traditions is the Star of Bethlehem. In the Bible however, this star is mentioned only in the Gospel according to Saint Matthew.

Chapter two begins: "After Jesus had been born in Bethlehem of Judea in the days of Herod the king, look! astrologers from eastern parts came to Jerusalem, saying: 'Where is the one born king of the Jews? For we saw his star when we were in the east and we have come to do him obeisance.'"

Later, after the wise men conferred with King Herod, the narrative continues: "When they had heard the king, they went their way, and look! the star they had seen when they were in the east went ahead of them, until it came to a stop above

Map Centered on 43° North Latitude

where the young child was. At the sight of the star they rejoiced very much indeed."

What was this star? Well, we may never know for sure, but the search for a naturally occurring Star of Bethlehem turns out to be one of the more interesting detective stories in astronomy. It is a mystery whose clues are dimmed by the passage of almost 2000 years. Another problem is the fact that the ancients considered almost every celestial apparition a "star".

Since the dates of many past astronomical events were either recorded or can be traced back with the aid of computers, it would be helpful to know when Christ was born. At first this might seem to be a silly question. After all don't we celebrate His birth on December 25, and count our years from that event? It seems that we are wrong in both instances.

First, it is more likely that Christ was born in the spring of the year rather than in winter. We are told by Saint Luke that there were shepherds in the fields watching their flocks at night. This practice, which continues today, occurs in spring when lambs are being born. Celebrating Christ's birth in December dates back to the Roman persecutions. By celebrating at the same time as the Roman feast of the Saturnalia, early Christians were less conspicuous and hence escaped detection.

As to His birth occurring 1,973 years ago, this too is in error. The practice of labeling the years A.D. and B.C. was not instituted until the year 525 A.D., when Dionysius Exiguus, the Abbot of Rome, determined the date of Christ's birth. Dionysius misinterpreted the historical records however, and there is at least a four year error in his determination.

Fortunately, there are a number of clues which will help us to more accurately set the date. First, Saint Luke tells us that the birth occurred during the reign of Augustus Caesar. Augustus was emperor of Rome from 31 B.C. to 14 A.D. Second, we have already seen that the birth was during the reign of King Herod. Herod came to power in 38 B.C., but it is more important to know the year of his death, since this will give us the latest possible date for the birth.

The Hebrew historian, Josephus, tells us that Herod died several days after an eclipse of the moon visible at Jericho, and at least one week before the feast of the Passover. Both of these events are determined by the position of the moon and therefore can be calculated quite easily. The eclipse occurred on March 13, 4 B.C., and Passover was on April 12 of that year. This narrows the years of our search down to 31 B.C. to 4 B.C.

Next we are told, again by Saint Luke, that

the family was in Bethlehem because of a Roman census. There were three of these head counts during the reign of Augustus — in 28 B.C., 8 B.C., and 14 A.D. Of the three, 8 B.C. is the most likely, and narrows our search again to the years 8 B.C. to 4 B.C.

A little deductive reasoning will enable us to narrow it still further. The census was decreed in 8 B.C. This decree had to be carried by messenger to Judea, on the outer reaches of the empire. Also, we have to allow time for the family to travel to Bethlehem. It is conceivable therefore, that as long as one or two years could have elapsed from the time of the decree, pointing to the years of 7 or 6 B.C. This also ties in with King Herod's slaying of all boys up to two years old when the wise men failed to return. Since this slaughter occurred late in his reign, it too points to 7 or 6 B.C. as the best years for our search.

Now that we know when to look, what is it that we are looking for? Although the ancient definition of a star was much broader than ours, there are several possibilities which can be ruled out right away. The Star of Bethlehem was not a bright meteor or bolide because it would have been too brief an event for the wise men to follow. A comet? They were considered an omen of evil. They heralded the death, and not the birth, of kings. Also there is no record of any comets appearing during those years. The records also show that there were no novae or supernovae visible in those years either. Another problem with novae is that they would have been visible to everyone, whereas we are told that only the wise men saw the star.

Who were these "wise men"? It is said that they probably came from Arabia. They were Magi, astrologer-priests of the Zoroastrian religion. As astrologers, they would have watched the motions of the planets, and read special meanings into their ever-changing positions. Was there then something in the positions of the planets that would have excited the Magi, but would have been ignored by the Hebrews, who did not believe in astrology?

This is an easy question to answer. With the use of modern computers, we can recreate the skies as they appeared then, and see them as the Magi did.

Looking into the early morning skies in April of 7 B.C., for example, we see the planets Jupiter and Saturn rising just before the sun. As we pass from April into May, the sun moves away from these two planets to the east. The planets in turn move closer together, because Jupiter takes less time to orbit the sun than does Saturn. On May 29, 7 B.C., in the constellation Pisces, the Fish, the two planets passed in conjunction between the stars Delta and Eta. This simple conjunction (occurring once every 20 years) would have

been astrologically viewed by the Magi as the king of the planets (Jupiter) visiting the planet of the Hebrews (Saturn) in the House of the Hebrews (Pisces).

After the conjunction, Jupiter continues to the east, moving away from Saturn. At the same time, however, Earth, moving faster in its orbit than either Jupiter or Saturn, begins to catch up to them. As Earth reaches opposition with Jupiter and then passes it, the giant planet seems to move "backwards" among the stars in retrograde motion. On September 29, 7 B.C., in Pisces, this retrograding causes Jupiter to pass Saturn in reverse, bringing the two planets again into conjunction.

By the middle of November, Earth has passed these planets and the retrograde motion stops. Proper motion resumes, bringing the two planets into conjunction for the third time on December 4, 7 B.C. — the third time in that year. This triple or "Great Conjunction" occurs only once every 125 years and rarely in Pisces.

To the Magi, these events would have been considered extremely important. As they saw it, astrologically the planet of the Hebrews was visited on three occasions in less than a year by the king of the planets, with all three meetings occurring in Pisces, the House of the Hebrews.

The Magi were also aware of the Hebrew prophecies concerning the birth of a great king that was to be heralded by a sign in the sky. And these conjunctions might well have sent them on their way to Bethlehem. There was, however, still one final act in this celestial drama.

As Jupiter and Saturn separated for the last time, they were being rapidly approached by the planet Mars. On February 25, 6 B.C., before Jupiter and Saturn could get very far apart, Mars joined them in a loose triangle in the vicinity of the stars Delta, Eta, and Omicron Piscium.

There is some question though, as to whether this final grouping would have been visible to the Magi as it was only 20 degrees away from the sun. If it was visible though, the planets would have been low on the western horizon at sunset — perhaps even appearing to "rest over the place where the child was".

This entire sequence of events is extremely rare, occurring only once every 805 years, with the last occurrence in the year 1604 A.D. In that year it was witnessed by Johannes Kepler, the first astronomer to really understand planetary motions. And in that year it was particularly spectacular as it was seen in connection with a brilliant nova.

Kepler calculated that these conjunctions would have been visible in 7 and 6 B.C., and was the first astronomer to suggest it might be a natural explanation for the Star of Bethlehem.

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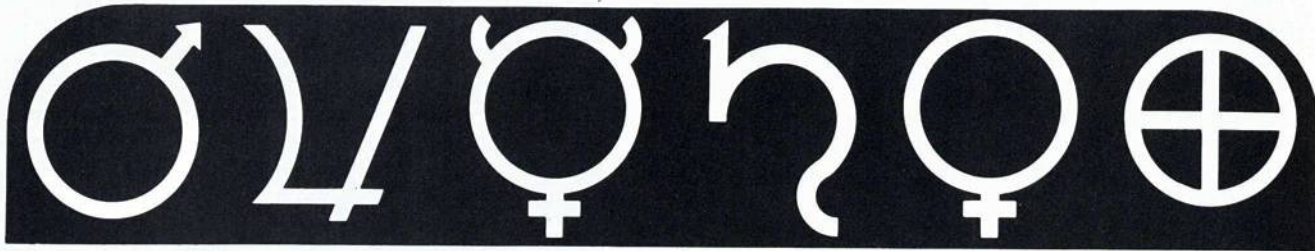
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SKY ALMANAC

Four Evening Planets, a Lunar Eclipse and the Pleiades Provide Delightful Viewing This Month

by
Terence Dickinson

This month, like the past four, is an excellent one for planet watchers. The four brightest planets are all in the evening sky: Venus and Jupiter in the southwest, Mars high in the south and Saturn in the east.

Saturn

The planet that discloses its gorgeous rings to the eye at the telescope appears in our winter skies as a brilliant zero magnitude star in the east, below the twin stars Castor and Pollux. Saturn will be with us the rest of the winter and this month it is closer to Earth than it will be for the next 12 months. The actual closest approach occurs on the evening of December 22 when Saturn is at opposition; that is, Earth, the sun and Saturn are very nearly lined up. Saturn's distance at that time will be 812 million miles. But for the whole month of December and through January the distance will change so little that this entire period is ideal for viewing the ringed planet. A major feature on observing Saturn appears in *Gazer's Gazette* in this issue.

Venus

Venus is normally the brightest object in the sky apart from the sun and the moon and this month it reaches its greatest brilliancy at magnitude -4.4. It's unmistakable in the southwest and for most of the month can be seen up to three hours after sunset. It's dazzling white, and this year makes a lovely Christmas star. Venus actually reaches greatest brilliancy on the 19th but for the rest of the month it is almost as bright, and with the unaided eye it's impossible to note the exact time when it reaches its peak. Through the telescope though, significant changes take place.

On the first of the month Venus is in its crescent phase as viewed through any small telescope appearing as a 39 percent illuminated disk 31 seconds of arc in diameter. By the end of the month it will have become 50 seconds in diameter and have shrunk to a thin sliver only 14 percent illuminated — a beautiful sight in any small telescope as the phase rapidly changes throughout the entire month.

By month's end the orbit of Venus is carrying

it between Earth and the sun and it becomes more difficult to observe in the last few days of the month. In January it will rapidly become invisible in the evening sky as it moves through the rendezvous point and out into the morning sky. So this month represents the most interesting period for Venus observing because of the rapid changes in the planet's position and phase.

Mars

December marks the last month that the surface features of Mars can be seen in small telescopes. As described in the September issue, Earth is now rapidly pulling away from Mars and it decreases in magnitude from a brilliant -1.1 at the beginning of the month to -0.2 by the new year. During that time its apparent diameter shrinks from 15-1/2 seconds to 11 seconds. To the unaided eye the red planet moves from the faint constellation Pisces into the only slightly brighter star grouping, Aries. During the closest approach of Mars in October and November, the planet was very well seen by observers in the United States. A selection of their photographs and drawings will be presented in future issues.

Lunar Eclipse

On the evening of December 9, a partial eclipse of the moon will be visible from most of North America. A partial lunar eclipse is, as one would expect, much less spectacular than a total eclipse. In a total eclipse the moon passes entirely into the shadow of Earth and becomes a coppery or dull brown color as it becomes immersed in the scattered light within Earth's shadow. This scattered, ghostly illumination is light that refracts and filters through the atmosphere around the circumference of Earth.

But this month's partial eclipse is unfortunately only slightly partial — only 11 percent of the moon is going to be within Earth's shadow. Here's an outline of the events as they will occur on the evening of December 9.

As it proceeds in its orbit around our planet the lower edge of the moon will first touch Earth's shadow at 8:09 p.m. (all times EST). The middle of the eclipse in which the lower 11 percent of the moon will be dipped in the dulling effects of Earth's cone-shape shadow will occur at 8:45 p.m. By 9:20 p.m. there should be no evidence of the shadow remaining as the moon proceeds on its inexorable trek about our world.

A much more spectacular total eclipse of the moon is not due until May 25, 1975, but that one will be worth waiting for. On that night the moon will become dramatically engulfed as it passes almost directly through the center of Earth's shadow.

Jupiter

Earth, in its smaller orbit, is pulling away from Jupiter and will soon put the giant planet too close to the sun for easy observation. But that won't happen until January. There is still one month of Jupiter observing left as the planet increases from 508 to 540 million miles from Earth. During December its equatorial diameter diminishes from 36 to 34 seconds of arc in apparent diameter — significantly less than its 48 second width in August.

Mercury

For the first day or two of the month the innermost planet may be seen in the southeast just before sunrise (see November issue). For the remainder of the month it is too close to the sun for observation.

SATELLITES OF JUPITER					
December					
10 p.m. E.S.T.					
1	4023	• ● • •	16	0243	● • • •
2	40123	• ● • •	17	21403	• • ● •
3	4210	• • • ●	18	43201	• • • ● •
4	4301	• • ● •	19	43102	• • • ● •
5	43102	• • • ● •	20	43201	• • • ● •
6	42301	• • • ● •	21	42103	• • • ● •
7	42103	• • • ● •	22	40123	• • ● • •
8	4023	• ● • •	23	41023	• • ● • •
9	01243	● • • • •	24	42103	• • • ● •
10	21304	• • • ● •	25	34201	• • • ● •
11	32014	• • • ● •	26	31042	• • • ● •
12	31024	• • • ● •	27	30214	• • • ● •
13	32014	• • • ● •	28	21034	• • • ● •
14	21034	• • • ● •	29	02134	• • • ● •
15	01234	● • • • •	30	10234	• • • ● •
			31	20134	• • • ● •

The positions of Jupiter's four brightest moons change hourly and daily, and make an interesting sight to view even in a small telescope or high powered binoculars. Shown above is the approximate appearance of Jupiter and its satellites as they might look in a small telescope at 10 p.m., EST. First column on the left shows the date. Second column of numbers identifies the moons and their position relative to Jupiter's disk. 1=Io; 2=Europa; 3=Ganymede; 4=Callisto, and 0=Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions.



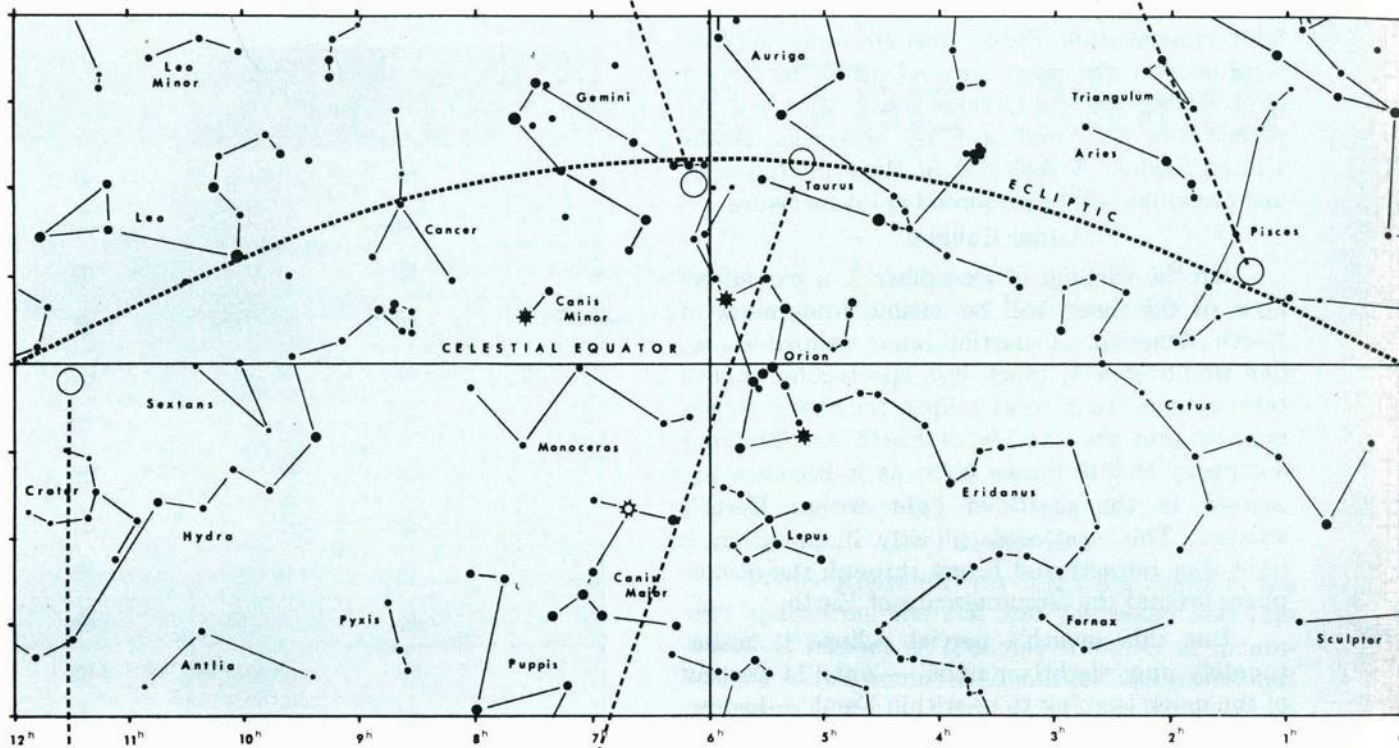
SATURN

December	1	16
R.A.	6 ^h 13 ^m	6 ^h 08 ^m
DEC.	+22°19'	+22°22'
DIST.	8.108A.U.	8.039A.U.
DIA.	18.4"	18.56"
MAG.	-0.2	-0.2



MARS

December	1	16
R.A.	1 ^h 34 ^m	1 ^h 42 ^m
DEC.	+10°06'	+11°24'
DIST.	0.5976A.U.	0.7080A.U.
DIA.	15.66"	13.22"
MAG.	-1.1	-0.7



THIRD QUARTER

December	16
R.A.	11 ^h 31 ^m
DEC.	-2°40'



FULL MOON

December	10
R.A.	5 ^h 05 ^m
DEC.	+23°52'



JUPITER

December	1	16
R.A.	20 ^h 44 ^m	20 ^h 55 ^m
DEC.	-18°55'	-18°09'
DIST.	5.480A.U.	5.666A.U.
DIA.	33.54"	32.44"
MAG.	-1.7	-1.7

This planet finder chart shows the positions of the sun, moon, planets and brighter asteroids for the current month as they appear against the background of the zodiac. Positions are plotted for the 15th with additional ephemerides for the 1st. To find zodiacal constellations visible during the current month, see Star Dome.

FIRST QUARTER

December 3
R.A. 22^h40^m
DEC. +2°59'

JUNO

December 1	16
R.A. 18 ^h 16 ^m	18 ^h 39 ^m
DEC. -13°58'	-14°05'
DIST. 3.889A.U.	3.934A.U.
MAG. +11.7	+11.7

PALLAS

December 1	16
R.A. 17 ^h 17 ^m	17 ^h 39 ^m
DEC. +3°56'	+3°31'
DIST. 4.011A.U.	4.050A.U.
MAG. +10.6	+10.6

NEPTUNE

December 1	16
R.A. 16 ^h 23 ^m	16 ^h 25 ^m
DEC. -20°00'	-20°05'
DIST. 31.292A.U.	31.252A.U.
DIA. 2.34"	2.34"
MAG. +7.7	+7.7

VESTA

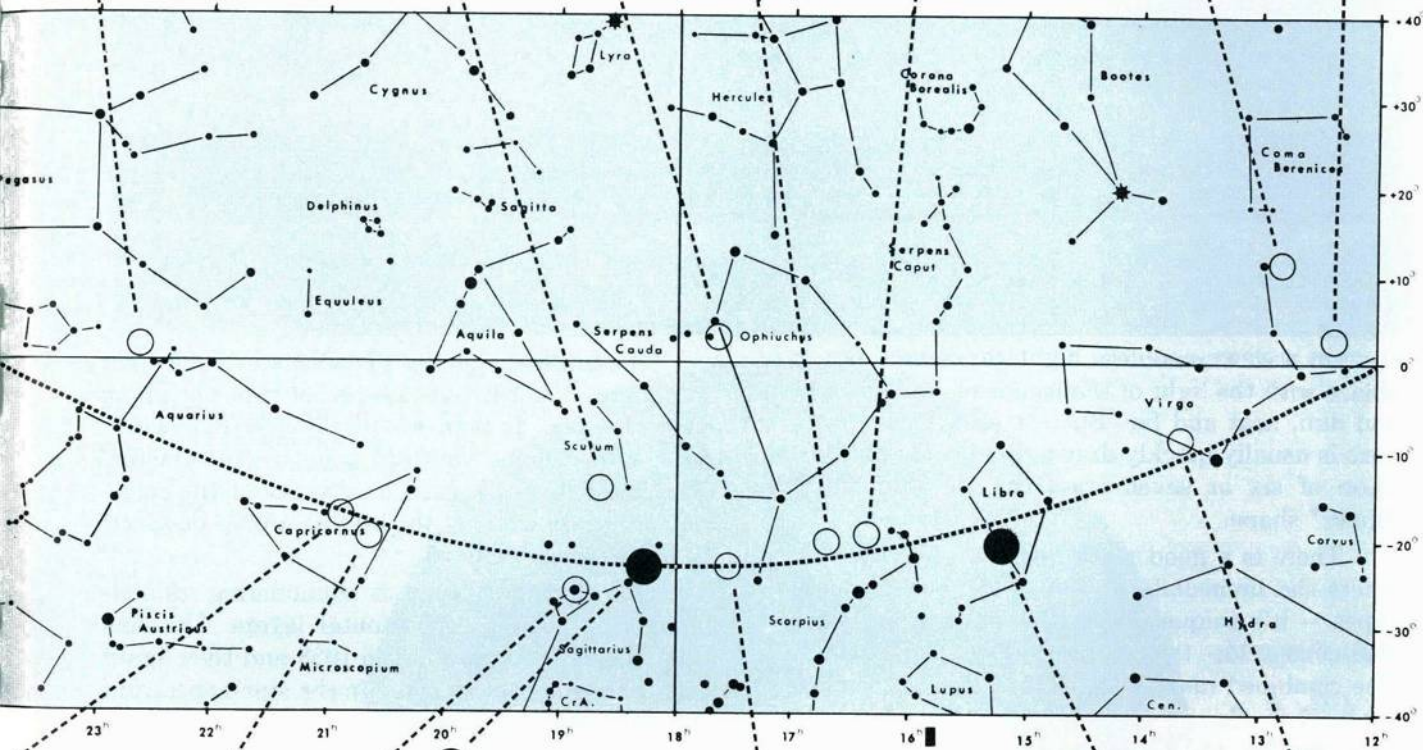
December 1	16
R.A. 12 ^h 05 ^m	12 ^h 26 ^m
DEC. +5°15'	+3°45'
DIST. 2.529A.U.	2.332A.U.
MAG. +8.1	+7.8

MERCURY

December 1	16
R.A. 15 ^h 09 ^m	16 ^h 36 ^m
DEC. -15°31'	-21°42'
DIST. 1.093A.U.	1.338A.U.
DIA. 6.1"	5.0"
MAG. -0.4	-0.5

PLUTO

December 1	16
R.A. 12 ^h 48 ^m	12 ^h 49 ^m
DEC. +12°34'	+12°36'
DIST. 31.365A.U.	31.171A.U.
MAG. +14	+14



NEW MOON

December 24
R.A. 18^h11^m
DEC. -23°03'

NEW MOON

November 24
R.A. 15^h18^m
DEC. -21°26'

CERES

December 1	16
R.A. 18 ^h 32 ^m	18 ^h 58 ^m
DEC. -26°55'	-26°45'
DIST. 3.736A.U.	3.828A.U.
MAG. +9.2	+9.3

URANUS

December 1	16
R.A. 13 ^h 38 ^m	13 ^h 40 ^m
DEC. -9°33'	-9°47'
DIST. 19.133A.U.	18.936A.U.
DIA. 3.58"	3.62"
MAG. +5.7	+5.7

SUN

December 1	16
R.A. 16 ^h 28 ^m	17 ^h 33 ^m
DEC. -21°45'	-23°18'
DIST. 0.9860A.U.	0.9841A.U.
DIA. 32'28"	32'32"

VENUS

December 1	16
R.A. 19 ^h 48 ^m	20 ^h 33 ^m
DEC. -24°07'	-20°25'
DIST. 0.5360A.U.	0.4293A.U.
DIA. 31.4"	39.2"
MAG. -4.2	-4.4

SATELLITE SHADOWS ON JUPITER

Date	Satellite	Transit begins EST	Transit ends EST
Dec. 1	4	in progress at dusk	5:26 p.m.
3	1	7:59 p.m.	10:16 p.m.
	3	10:07 p.m.	1:44 a.m.
6	2	7:25 p.m.	10:16 p.m.
10	1	9:54 p.m.	12:11 a.m.
12	1	4:23 p.m.	6:40 p.m.
13	2	10:02 p.m.	12:53 a.m.
19	1	6:18 p.m.	8:36 p.m.
26	1	8:14 p.m.	10:31 p.m.

1 = Io
2 = Europa

3 = Ganymede
4 = Callisto

The Pleiades

On a clear moonless night the winter sky is ablaze with the light of thousands of stars, bright and dim, near and far. But the casual observer's gaze is usually quickly drawn to a small configuration of six or seven stars that form a "little dipper" shape.

There is a good reason why the Pleiades attracts the immediate attention of nonastronomy types — it's unique. There is no other star cluster that comes close to the brightness of the Pleiades. The combined magnitude of the stars in the cluster is +1.6. This surprisingly high overall magnitude can be confirmed if you are nearsighted. Simply take off your glasses and look at the Taurus region. The Pleiades will appear like a fairly bright out-of-focus star. So taken as a unit this group is far brighter than any other compact cluster in the sky.

The Pleiades are best seen in binoculars or a short focus telescope that gives a two degree or greater field of view. Any smaller field, and the real beauty of the cluster is diminished.

The Pleiades is not an accidental grouping of stars. The approximately 400 stars in the cluster were all formed about 20 million years ago from a huge cloud of dust and gas, the faint remains of which are seen as nebulosity in our cover photo this month and the above amateur made photo. Unlike the Orion nebula this one only reflects

the light of the stars embedded in it.

The brightest of the Pleiades stars, Alcyone (pronounced Al-SEE-oh-nee), is 500 times brighter than the sun. It shines with intense blue-white light as do all the youthful stars in this cluster. They're really baby stars hardly out of the celestial maternity ward — the brightest ones destined to be the shortest lived.

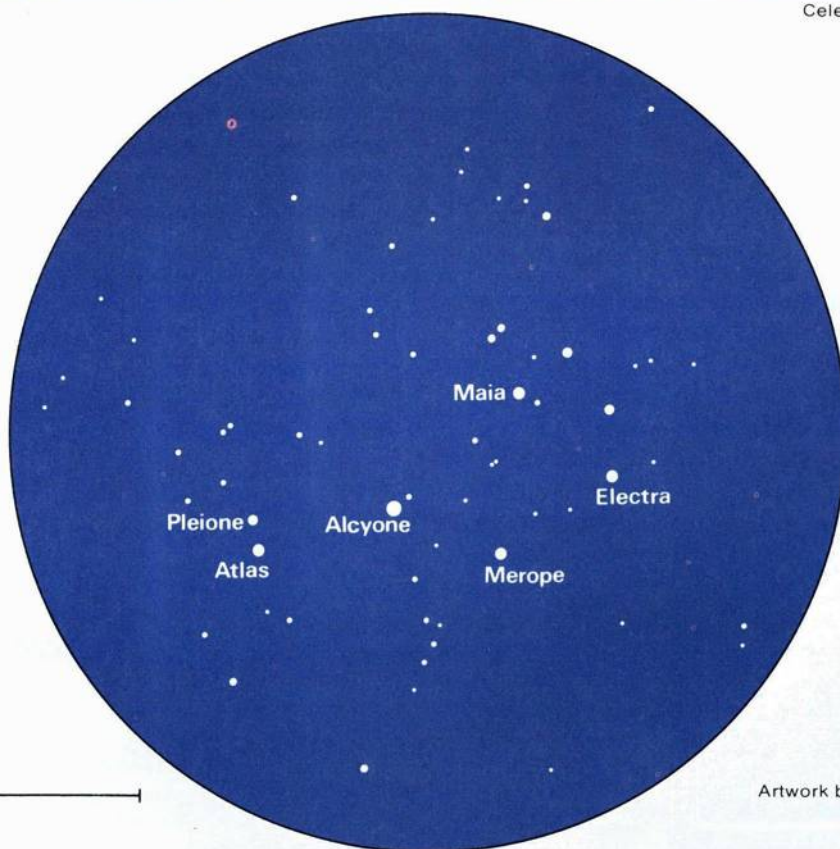
One of them, Pleione is squandering its stellar fuel by puffing off its outer layers. This has been observed twice. First in 1938 and then again this year astronomers noted in the star's spectrum definite evidence of ejection of a "smoke ring" of matter. This unusual behavior is undoubtedly linked to Pleione's distinction as one of the most rapidly rotating stars known, turning completely every six hours (100 times the sun's rate). Many of the other Pleiades stars are also rapid rotators.

The entire cluster is about 50 light-years in diameter and 500 light-years distant. Near its center the stars are two light-years apart on the average. The entire cluster of stars is slowly dispersing and will be unrecognizable as a cluster in about one billion years.

Although a one billion year lifetime sounds long it is relatively short for a star cluster — there are many much older and more compact. In the cosmic time scale the Pleiades is as transient as a billowy cloud on a bright summer afternoon.



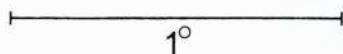
Celestron Pacific Photograph



Magnitudes:

- 3rd
- 4th
- 5th
- 6th
- 7th
- 8th

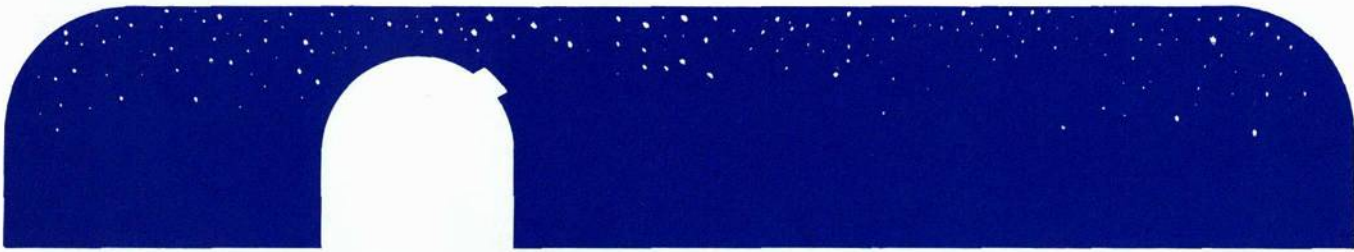
Scale:



Artwork by Victor Costanzo

Even amateur photographs of the Pleiades will reveal the delicate reflection nebulosity as this eight inch Schmidt camera photo shows. In the diagram the visual appearance of this star cluster is illustrated along with names of the

brighter members of the group. Alcyone is 3rd magnitude but the rest are 5th or fainter. The circle is a $2\frac{1}{2}^\circ$ field of view — about that obtained with high power binoculars or very low power short focus telescopes. 



PUBLISHER'S MEMO

It seems at times that no matter what a new magazine does to make itself fresh and innovative, it falls into the pitfall of the "staid" and "old hat". We think this has happened to us with one of our departments — Letters to the Editor. This department title is a label that was easy to think up which required little creative thought.

We don't like that title — "Letters to the Editor" — it makes us yawn with boredom. So ... we're starting a contest among our readers: Name the ASTRONOMY Letters Department.

We will award a cash prize of \$25.00 for the most creative letters department title submitted by our readers. Naturally, the best title will be used in ASTRONOMY and the winner will be announced in the March issue. Keep the title short and make submissions before January 2, 1974. Send your entries to ASTRONOMY, Letters Contest, 757 North Broadway, Suite 204, Milwaukee, Wis. 53202.

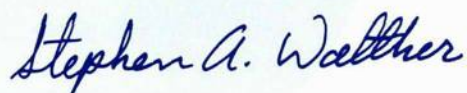
Turning to another arena momentarily, we're blushing pink — we made a whopper of a "boo-boo" in the October issue. On page 33 of that issue, the lower left hand diagram of Comet Kohoutek in the morning sky — it should read "Exact SE Point. SE Horizon 1 Hour Before Sunrise". Although frankly, we must admit it would be interesting — to say the least — to see

the celestial vault "rise" in the west!

Oh my readers I am heartily sorry for having offended thee In the November issue we inadvertently omitted photo credit lines for James Cross' picture of Lyra (page 44 left), and Thomas Bretl's photo of star trails (page 41).

In spite of the goofs last issue, you may have noticed ASTRONOMY is 16 pages larger. Further, ASTRONOMY is now printed on a higher quality paper by another printer — the W.A. Krueger Co. We're thoroughly pleased with the color and black and white reproduction quality this new printer is able to provide us — and most importantly, you.

One final comment: we have temporarily discontinued the "Sky Almanac" section on variable stars by R. Newton Mayall. Specifically, we have had innumerable complaints about the finder maps used with this section. The confusing lack of scale and poor star orientation have prompted us to improve the quality of these maps and the department. Our cartographer, Raymond G. Coutchie, in cooperation with the American Association of Variable Star Observers, will design finder maps that are clear, concise and foolproof, so that anyone can locate the month's highlighted variable. We will resume publication of this section in March or April, 1974.



Stephen A. Walther
Publisher

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1268 ANDROMEDA NEBULA

ASTRO GRAPHICS

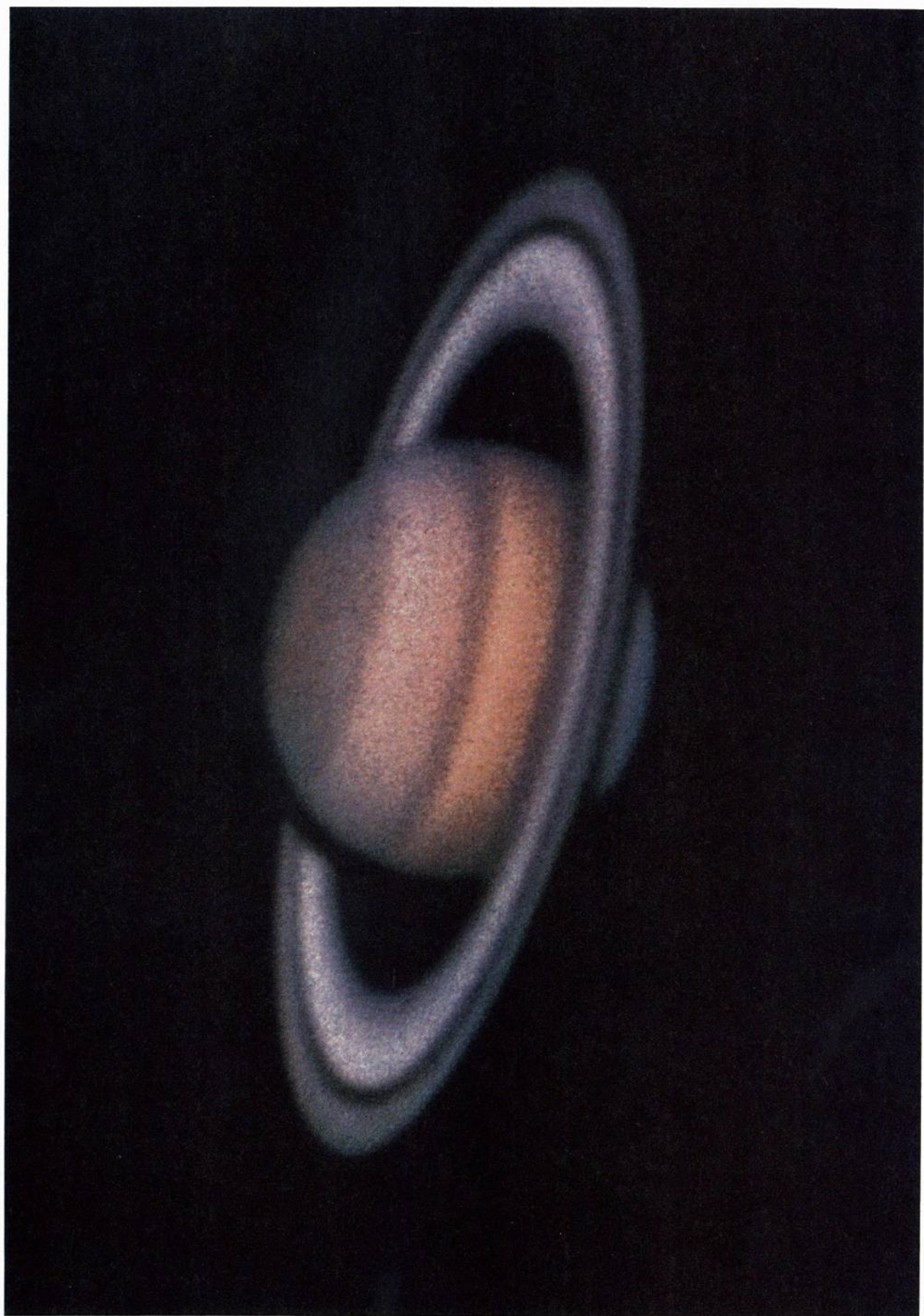
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GAZER'S GAZETTE

Can I Really See Saturn's Rings?

by
Terence Dickinson

Probably everyone who has seen Saturn through a telescope vividly recalls the experience. If you haven't, you are missing one of the most inspiring and beautiful sights that a telescope can offer.

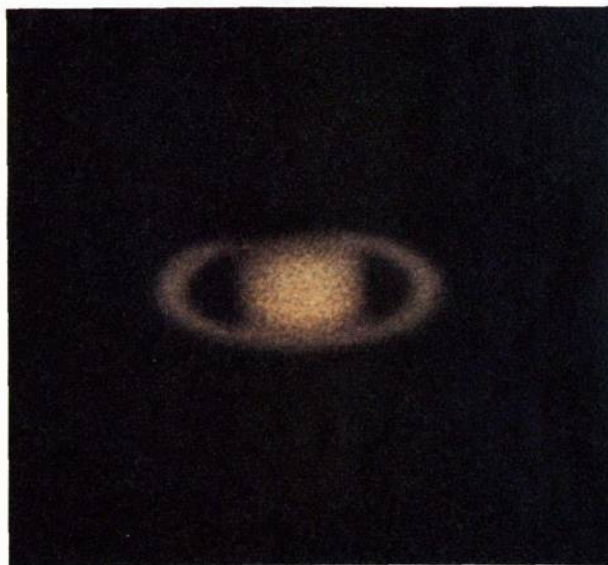
Even a 60mm refractor shows the yellow orb as clearly as it looks in photographs. Looking across 800 million miles of space at a world as alien to Earth as a planet can possibly be, the rings seem like a magic wheel hovering around a pale marble.

Novice observers who have never viewed Saturn in a telescope will be amply rewarded by a view of the planet's rings — even at 40 power. Titan, the largest of Saturn's moons, can be clearly seen as a starlike object which changes position nightly relative to the planet.

The Planet

The disk of Saturn appears as an essentially featureless sphere, about one-sixth the size Jupiter appears through the same telescope at the same power. In telescopes less than four inches aperture probably no features will ever be seen on the surface of the planet. As the size of the telescope is increased, the first thing that will become apparent is the whitish equatorial region and the darker polar regions.

Basically Saturn has a belt system like Jupiter's but it is much less active and the contrast is reduced. (Both Jupiter and Saturn have immense atmospheric cloaks that are topped by

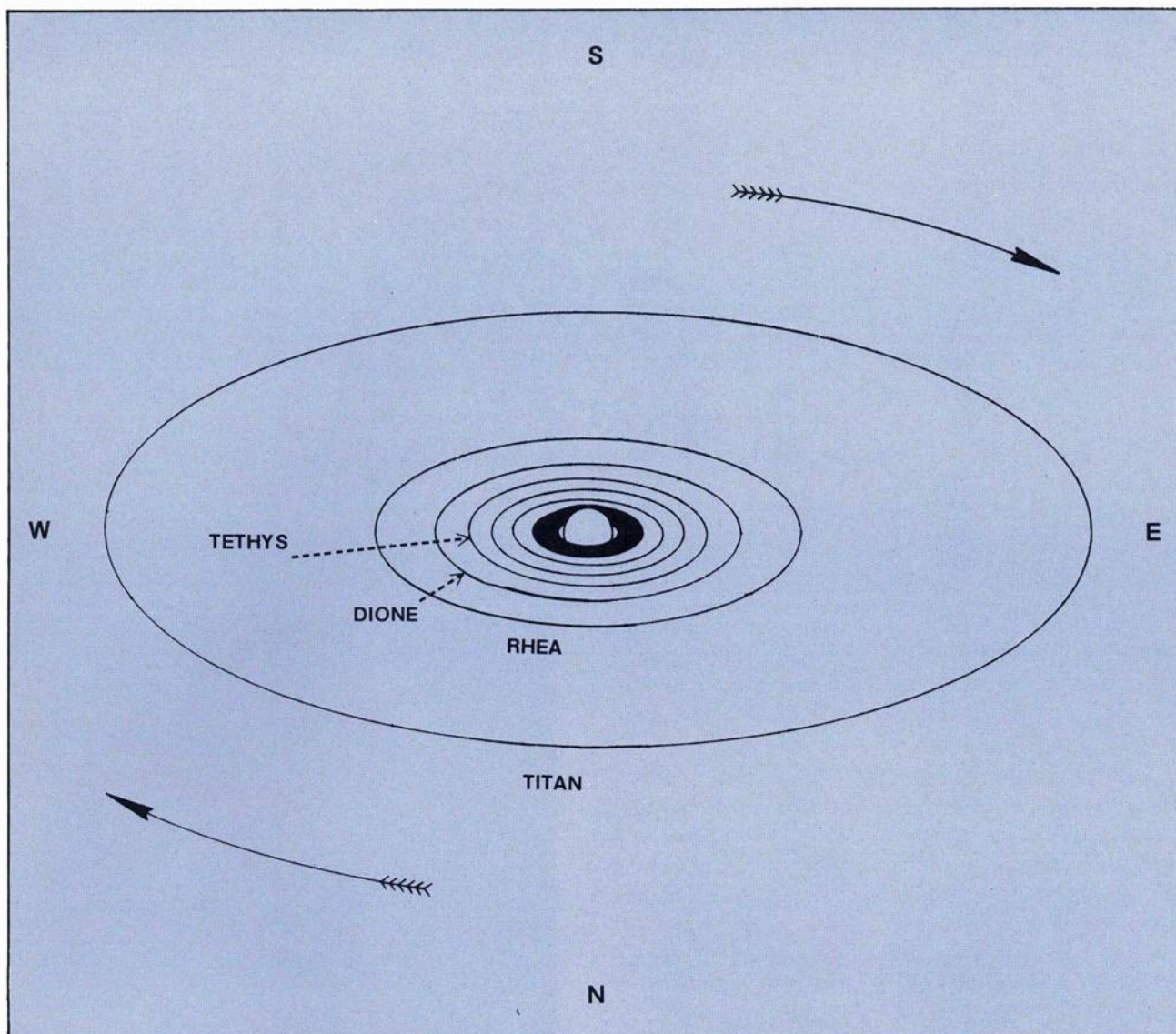


Photograph by Steven Reed



Celestron Pacific Photograph

All winter and on into next spring the ringed planet will be in southern Gemini. At magnitude -0.3 in late December it will be brighter than at any other time in the last half of the 20th century.



The orbits of six of Saturn's satellites are shown here. The two unnamed inner moons are Mimas and Enceladus. Of the remaining moons not shown here only Iapetus is easily seen in amateur instruments. The satellites shown in Victor

Costanzo's rendering of Saturn through a 12 inch telescope can be identified by using this chart. Consult the table "Locating Saturn's Satellites" to make full use of this chart. South is to the top as seen in inverting telescopes.

multicolored ammonia clouds. But the colors and activities in the Saturn clouds are a poor second to Jupiter's bold stripes.) Only in very large amateur telescopes do more than one or two belts come into view or any evidence of cloud features become apparent. Very rarely a spot among the clouds of Saturn will appear unexpectedly but less than a dozen notable spots have been recorded since observation of Saturn by telescope commenced in the 17th century.

These spots have, however, proved to be vital in determining the rotation period of the clouds at various latitudes. On the equator for example the rotation period is about 10 hours 14 minutes. The belts on either side of the equatorial zone have an average rotation period of 10

hours 17 minutes and beyond that the atmosphere circulation slows down considerably to about 10 hours 37 minutes in the zones between 35 and 40 degrees from the equator. Up around the poles it's something like 11 hours but this is still debated.

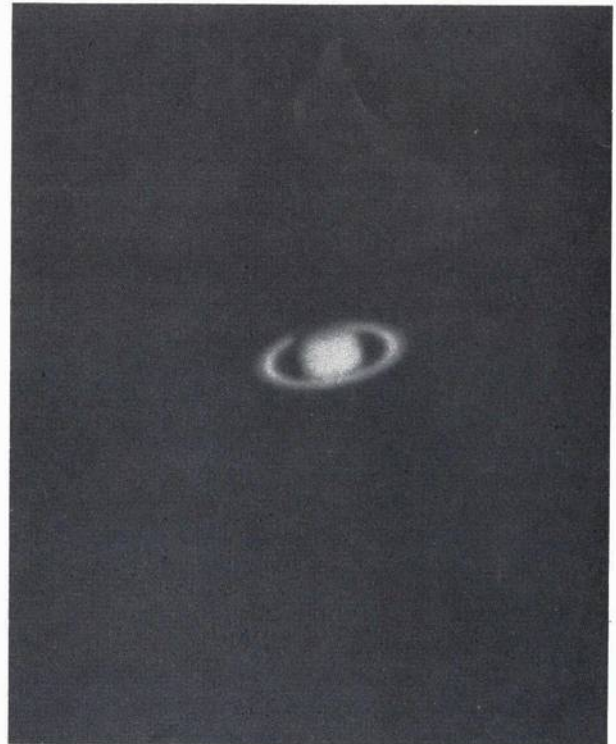
In any event the rotation period will not be at all as evident as it is in the case of Jupiter unless a rare spot happens to emerge during the next few months. Modern observers can probably make only one significant discovery about Saturn and that is the detection of one of these spots — usually a white oval — that will allow a fresh determination of the rotation of the clouds. Such spots are so rare that when they are seen they are named after the discoverer, like a comet.

The Rings

From year to year the rings take on quite different appearances. The orbit of Saturn is an immense 29-1/2 year circuit about the sun so in the course of an observing season, say four months or so, the planet moves relatively little in its orbit and thus appears to remain about the same place among the stars — this year it happens to be the constellation Gemini.

Right now the rings are presented to their fullest extent as viewed from Earth. In 1966 and again in 1980 the rings are seen from Earth edge-on and at that time effectively disappear from view. In apparent width, the rings are equal to the equatorial diameter of Jupiter, but they seem smaller.

At the present time the north side of the rings and the northern hemisphere of Saturn are presented to our point of view. The equator of Saturn is tilted to the plane of its orbit by 27 degrees and it is this tilt that causes the rings to tip toward and then away from us as Saturn has its seasons. Earth does the same thing as viewed, for example, from the sun. First the northern hemisphere is presented to the sun; then six months later, the



Photograph by Steven Reed

The 1971 appearance of Saturn and its rings. The rings are more fully open to our view in 1973 and 1974.

LOCATING SATURN'S SATELLITES IN DECEMBER

Titan		Rhea		Dione		Tethys	
Dec. 11	2 a.m.	Dec. 5	1 p.m.	Dec. 2	10 p.m.	Dec. 1	7 p.m.
26	11 p.m.	9	1 a.m.	5	4 p.m.	3	4 p.m.
		14	1 p.m.	8	10 a.m.	5	2 p.m.
		19	1 a.m.	11	4 a.m.	7	11 a.m.
		23	1 p.m.	14	9 p.m.	9	8 a.m.
		28	1 a.m.	16	3 p.m.	11	5 a.m.
				19	9 a.m.	13	3 a.m.
				22	2 a.m.	15	1 a.m.
				24	8 p.m.	16	9 p.m.
				27	1 p.m.	18	7 p.m.
				30	7 a.m.	20	4 p.m.
				Jan. 2	1 a.m.	22	1 p.m.
						24	11 a.m.
						26	7 a.m.
						28	5 a.m.
						30	2 a.m.
						31	11 p.m.

On the dates and times (EST) indicated here, the satellites will be at their extreme eastern orbital point. To calculate for other dates use orbital period to determine position.



Copp Clark Publishing Corp. Artwork

(A) In a large telescope (12 inch or greater) under excellent seeing, Saturn is a magnificent sight. When the rings are seen fully open to earthbound observers the Cassini gap is easily seen as well as the elusive innermost "crepe" ring.

(B) In four years Saturn will have moved far enough in its ponderous orbit to give us a more oblique view of its ring system. We are still viewing the south face of the rings. Some of the north polar region has come into sunlight again after a dark winter that lasted for over four years.

(C) In 1980 the rings will seem to close to a delicate thread of light. Eventually they will disappear from view altogether as Earth intersects the plane of the rings. When this last happened (in 1966) an inky shadow was the only evidence of the rings. They had dramatically vanished from sight — a testimony to their remarkably thin nature.

(a) Saturn as it appears in a typical 60mm (2.4 inch) refractor. Titan is to the right (east). (b) A four inch telescope brings the Cassini gap and a second moon, Rhea, into view. (c) With a 12 inch telescope Saturn and its moons are spectacular. This view at about 275 power reveals the planet's light equatorial zone and a few of the faint cloud belts. Six moons are seen although Mimas, the nearest, is extremely difficult to detect. The moons are shown as they will appear on December 23 at 9 p.m. EST. The rings, crisp and brilliant, cast their shadow on the globe of Saturn. The crepe ring is glimpsed along the inner edge of the main ring. This rendering, by Victor Costanzo, duplicates the view in a 12 inch telescope in good seeing.

2" Telescope

50x



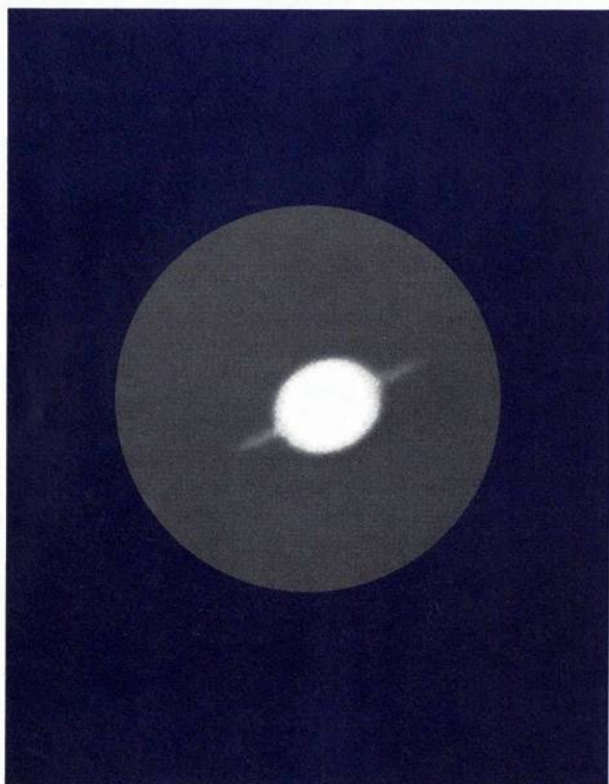
4" Telescope

125x



12" Telescope

275x



Photograph by Steven Reed

In 1966 Saturn's rings were "edge-on". Steven Reed captured their appearance by overexposing this photo taken in that year through an eight inch telescope.

southern. In the case of Saturn's large orbit, first its northern hemisphere is tipped to Earth and sun; then fifteen years later, the southern hemisphere is presented to our view.

The rings are more reflective than the planet and when they are open to the extent that they are this year, Saturn appears as bright as it possibly can be — magnitude -0.3. This will make it brighter than everything in the overhead region of the sky this winter.

Saturn, probably more than any other planet, can be subjected to very high telescopic powers. Perhaps it is because of its low surface brightness (due to its tremendous distance from the sun). From 30 to 50 magnifications per inch of telescope aperture will give excellent views of Saturn if the atmosphere is at all calm. The division in the rings (Cassini's division) about 4000 miles wide, can be seen with a three inch refractor under good conditions and is easily observed with four inch and larger telescopes. A second division, Encke's, is located about midway through the outer, smaller ring and usually requires at least a six inch telescope and sometimes even a 12 inch instrument will not reveal it. Other divisions in the rings have been reported but none are within the range of amateur instruments even if they do exist.

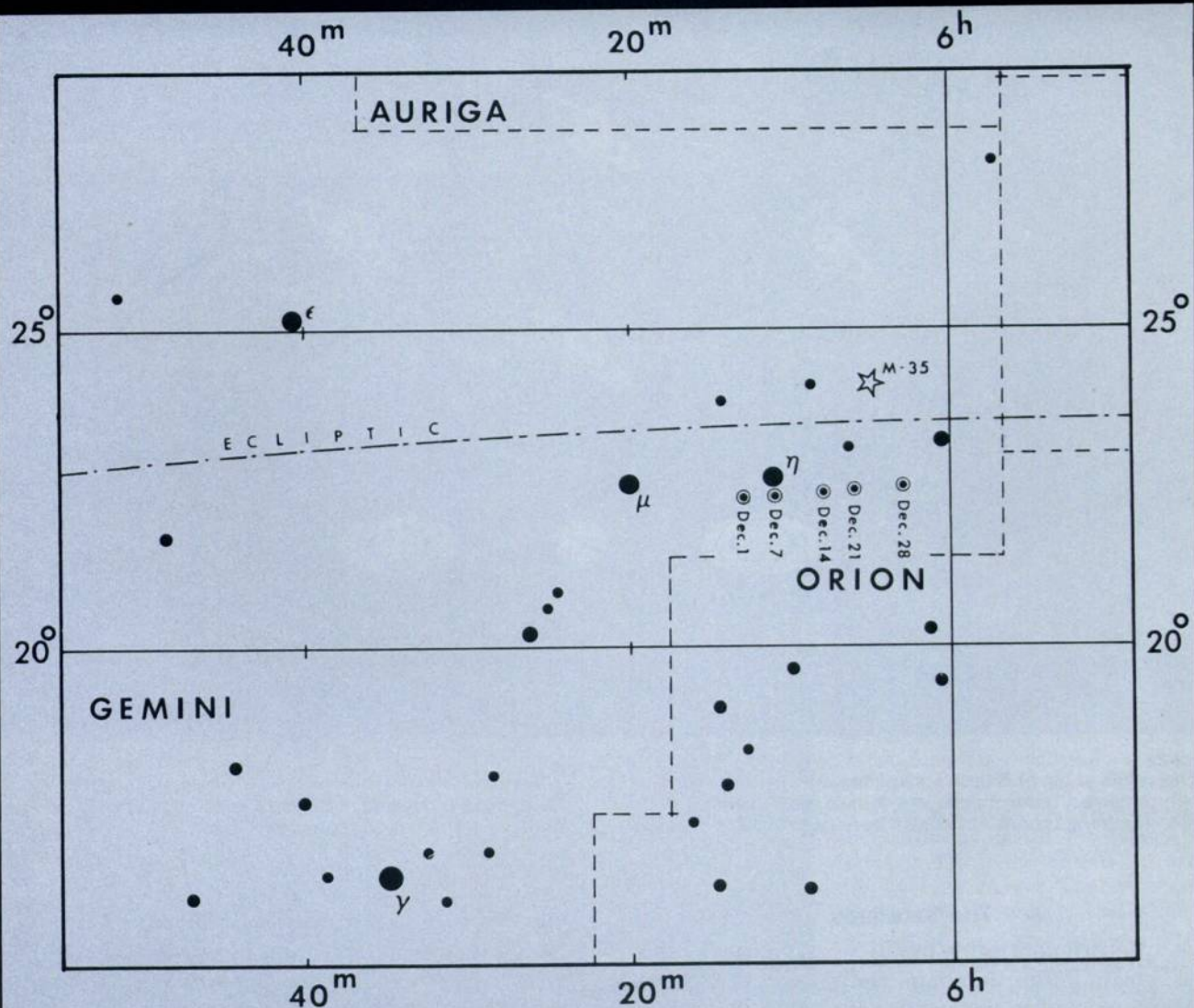
SATURN'S SATELLITE FAMILY

Name	Magnitude	Orbital Period		Distance from Saturn *	Minimum Aperture for detection
		Days	Hours		
Janus	14	0	18.0	100	**
Mimas	12	0	22.6	116	12 inch
Enceladus	12	1	8.9	148	10 inch
Tethys	10.5	1	21.3	183	8 inch
Dione	10.5	2	17.7	235	6 inch
Rhea	10	4	12.5	327	3 inch
Titan	8.5	15	23.3	759	2 inch
Hyperion	14	21	7.6	920	12 inch
Iapetus	10 to 12	79	22.1	2213	3 inch
Phoebe	16.5	523	15.6	8053	**

* thousands of miles

**observed only with sophisticated equipment

MOTION OF SATURN



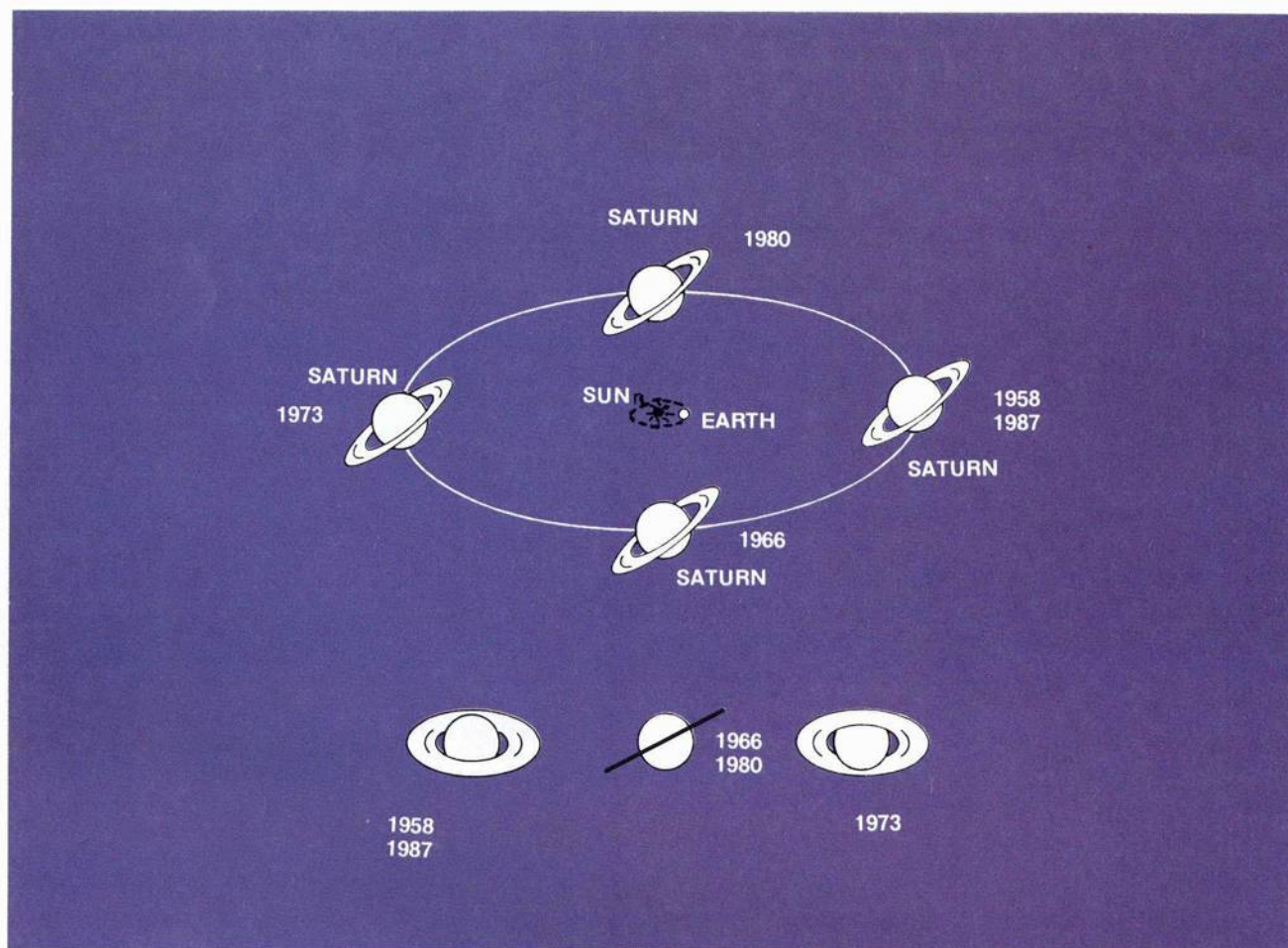
Map by Raymond G. Coutchie

Magnitudes

- ☼ Zero
- First
- Second
- Third
- Fourth
- Fifth

Objects

- ★ Open Clusters
- ⊙ Globular Clusters
- Diffuse Nebulae
- ☾ Galaxies
- ^d Double Stars
- ^v Variable Stars



The orbits of six of Saturn's satellites are shown here. The two unnamed inner moons are Mimas and Enceladus. Of the remaining moons not shown here only Iapetus is easily

seen in amateur instruments. The satellites shown in Victor Costanzo's rendering of Saturn through a 12 inch telescope can be identified by using this chart.

The Satellites

Saturn controls a family of 10 moons — one of which, Titan, is about the size of the planet Mercury, and is known to have an extensive atmosphere of mainly methane gas. Titan orbits Saturn in about 16 days and when it is east or west of the planet appears about five ring diameters away from the center of Saturn.

Titan can be seen in a two inch or larger telescope. The table on page 50 gives complete details on the satellite system. Of the remaining moons, Rhea is the only one easily seen in telescopes less than six inches in aperture. Its orbit lies well within Titan's.

One of the most mysterious objects in the solar system is Saturn's ninth moon, Iapetus (pronounced eye-yap'-petus). For some totally unknown reason one side is six times brighter than the other. When this moon is to the west of Saturn it is tenth magnitude and can be picked up with a three inch refractor. (Look for it in the first two weeks of February about 12 ring dia-

meters west of Saturn.) But when it reaches the opposite side of its orbit 11 weeks later it has faded to 12th magnitude and is difficult to find in a much larger scope. No satisfactory explanation has been offered to account for the unique nature of Iapetus.

Moons like Dione and Tethys make excellent targets for larger amateur instruments (see tables). They are often nestled in the glare of the rings but finding them is a rewarding pastime. Try using "averted vision" if you are having trouble. Look away from Saturn but concentrate on the region around it. Often a faint satellite will pop into view as it registers on the sensitive regions of the eye away from the center of vision.

Janus, Hyperion, and Phoebe are beyond amateur instruments and Mimas and Enceladus challenge the experienced observer.

With its unique rings and variety of moons Saturn is a worthy subject for any telescope, large or small. Now if only we could do something about the weather. ☁

ASTRO-NEWS

Latest News From the World of Astronomy

New Theory On How Asteroids Form

An explanation of how planetesimals — small planet-like bodies only a few miles in diameter — formed from dust condensed out of cooling solar gases has been proposed by two California Institute of Technology scientists.

In their paper in the *Astrophysical Journal*, Drs. Peter Goldreich and

William R. Ward attempt to answer the question of how fragments no bigger than dust or gravel particles "grew" into asteroid-size bodies.

This unanswered puzzle has for years been an important gap in scientists' understanding of the process by which planets evolved as satellites of the sun. According to Goldreich and

Ward, the first step toward solving this puzzle was taken in the 1960s, when scientists specializing in the chemistry of space showed how debris the size of dust and even small gravel particles could have condensed out of the slowly cooling gases in the nebula around the newly formed sun. Scientists believe this debris represents the first stage in the evolution of planetary bodies.

Further along in the evolutionary process, it was suggested that planet-sized bodies could have formed as the product of a series of collisions of smaller objects. The gravitational fields of these asteroid-like bodies would have caused them to stick together once they collided — creating one body the size of the original two.

But scientists had been perplexed about what happened in between. Now, however, Goldreich and Ward believe they have the answer. The two researchers describe the process this way:

As the gases around the sun began to cool, the solid particles that condensed out of it formed a thin, plate-like disk of debris in orbit about the sun. In the inner solar system this debris probably consisted mostly of iron and magnesium silicates — the substances most abundant in the inner planets — while in the outer solar system, the material was primarily water and water-ammonia ices. But although the gravitational pull of any one fragment was virtually negligible, the combined mutual gravitational attraction of countless numbers of these tiny objects was sufficient to break up the newly formed disk.

The little particles drew into separate clusters, each cluster composed of bits of debris all attracting one another. The space between the particles continued to shrink until eventually portions of each cluster collapsed on themselves to form larger objects.

continued on page 54

New Views On Kohoutek



Lunar and Planetary Laboratory Photograph

The above photograph shows a superimposition of three photographs made by the Lunar and Planetary Laboratory Schmidt telescope on October 29, 30 and 31 at 5 a.m. MST. The photograph dramatically shows the motion of Comet Kohoutek during a three day period. The magnitude of the comet was about seven or eight and notice the gradual development of a tail. When Kohoutek was photographed, it was in the constellation Virgo. Photographers at LPL were R. B. Minton and Stephen Larson.

Titan May Support Life

Recent discoveries strongly suggest that Titan — the largest moon of the planet Saturn — is far more earth-like than anyone ever suspected. It could be the home of a variety of life forms according to Cornell University astronomer, Dr. Carl Sagan.

The change in thinking is due to new evidence obtained at several observatories, showing that the atmospheric pressure on Titan resembles Earth more than any other planet. The atmosphere consists of methane, ammonia, water and hydrogen in amounts that may produce 50 percent of the pressure our earthly atmosphere does here. If these estimates are correct then there is certainly enough atmosphere to provide active weather systems and a crucible for life.

Sagan, director of Cornell's Laboratory for Planetary Studies is an internationally recognized expert on exobiology — life beyond Earth. He explains that the 3,000 mile diameter Titan is almost entirely ice except for

a small molten core which melts the ice far below the surface, forming volcanoes that belch forth the melted water, ammonia and methane.

Once released and exposed to sunlight, the molecules in the atmosphere go through a series of complex changes. In a simulation of the atmosphere of Titan at Cornell, a reddish brown compound of organic molecules has been produced. Sagan finds this of special interest since the clouds of Titan are known to be reddish.

These clouds, along with abundant hydrogen from the volcanoes form a blanket over this improbable world that acts like a green house. It is so effective that the temperature on Titan is about 90 degrees below zero — like that at the south pole of Earth — much higher than previously believed.

Baffled by these new discoveries, astronomers are trying to account for the continued existence of a substantial atmosphere on a world with surface

gravity only slightly greater than the moon's. Of course the volcanoes mentioned by Sagan are a factor but two other Cornell scientists, Thomas R. McDonough and Neil M. Brice, have suggested another.

The escaped atoms from Titan's atmosphere, they explain, would probably form a gaseous ring around Saturn and be recycled back into the Titan atmosphere by capture during the moon's orbital circuits.

In this way the Cornell astronomers calculate the net loss of Titan's atmosphere would be reduced to three percent of what it would be otherwise.

Secondly they suggest that Saturn's magnetic field may capture hydrogen atoms from the solar wind and thus provide additional supplies for Titan to sweep into its atmosphere.

The exact nature of the clouds and atmosphere of Titan may be determined in 1981 by Mariner 11, tentatively scheduled to fly within 100 miles of the big moon. This mission is an unmanned four year Jupiter-Saturn photographic flyby flight but Sagan and others are pushing for more emphasis on the Titan investigations that were previously considered a very minor aspect of flight plan. ☛

New Asteroid Theory, continued from page 53

As portions continued to draw together and collapse, they formed objects of increasing size, eventually becoming about half a mile in diameter. By this time, objects had been formed that had a significant gravitational field of their own. These bodies — much larger than the original fragments of rock and yet far too small to be planets — are called planetesimals. Their formation took place on a time scale that is incredibly fast, as cosmic time is measured.

"It took only a few years to produce bodies that were half a mile thick," Ward said. "Clusters containing about 10,000 of the planetesimals continued to rotate around themselves in a delicately balanced equilibrium — prevented from contracting to form one object by the strength of their rotational patterns."

But the planetesimals interacted with the hydrogen gas that formed most of the remaining solar nebula, and the gas produced a drag which drained away the energy in their rotation. This drag caused the clusters to continue to contract upon themselves, although much more slowly than when the particles were smaller

and their orbits more unstable. Over a period of several thousand years they had formed still larger planetesimals, about five miles in diameter.

Objects this size are as large as the two scientists believe could have formed through the proposed process. But by this time, the larger planetesimals would have continued to grow by collecting smaller pieces as they encountered them. Their gravitational fields would have been strong enough to cause the encountered fragments to stick when they collided.

Goldreich and Ward believe this process has taken place many times in the universe — around every sun that has a solar system.

"The formation of planets is very likely a natural consequence of the formation of stars," Ward said. "It has been suggested that when gas collapses to form a star, one of two things happens — sometimes multiple stars are formed, and sometimes a star with a solar system is formed."

"If that is true, then we could expect there to be as many stars with solar systems as there are multiple stars — and we see a tremendous number of those." ☛

Comet Kohoutek Living Up To Expectations

The "great comet of the century" seems to be developing into just that according to Dr. Brian Marsden of the Smithsonian Astrophysical Observatory. Marsden says the comet is "living up to our prediction concerning its brightness and tail". This means it will achieve naked eye visibility in mid-November.

On Oct. 15 Dr. Elizabeth Roemer obtained a photograph with the Lunar and Planetary Laboratory's 40 inch telescope, showing a substantial dust tail on Kohoutek. The dust tail is the important area for visual observation. A good dusty tail means a bright, easily visible comet.

The best time to view Kohoutek is still the second and third weeks of January when it will be in the dark western skies after sunset. The information and predictions in the October issue need not be updated according to these latest findings. ☛

Jupiter To Have Its Temperature Taken

Over the past few years a number of astronomers have reported convincing evidence showing that the planet Jupiter radiates more energy than it gets from the sun. If so, why? How close is Jupiter's composition to that of the sun? Is it part star and part planet?

These vital questions may be answered when a small spacecraft, Pioneer 10, gives man his first close look at the solar system's largest planet early in December. Pioneer will fly within 100,000 miles of the 88,000 mile diameter planet Dec. 3 after a journey of nearly two years.

Crucial information related to these important questions will be obtained by one of the 13 experiments aboard Pioneer, an infrared radiometer similar to those flown on the Mariners that closely observed the planet Mars.

"There are indications that Jupiter emits up to 2-1/2 times more energy than it receives from the sun," reports Dr. Guido Munch, of the California Institute of Technology. "In this respect it resembles a star more than a planet. It is believed that this energy comes from the release of gravitational

energy from the slow contraction of the whole planet. This contraction is so small — only about one millimeter (1/25 of an inch) per year — that we cannot measure it directly.

"Jupiter has a very deep atmosphere composed largely of hydrogen in which are suspended solid particles of ammonia ice and other condensed ammonium compounds," said Munch, the principal investigator of Pioneer's infrared radiometer experiment.

The very intricate cloud patterns seen on the disk of the giant planet are the result of condensation and evaporation processes affecting ammonia and its compounds. In Jupiter's atmosphere, ammonia plays the same role as water does in the earth's atmosphere.

However, unlike Earth, below Jupiter's atmosphere there is no solid surface of radically different composition. Instead the pressure increases with depth to a level where the gases become liquid — at a pressure of 100,000 atmospheres. Deeper down in the interior of the planet is a shell of solid molecular hydrogen. And at pressures around two million atmospheres hydro-

gen becomes metallic. A slow conversion of hydrogen from its molecular form to its metallic phase results in contraction and the release of energy in the form of heat at the center of this colossal world.

It is believed that the gross composition of Jupiter is similar to that of the sun, Munch noted. If so, he added, helium should be present along with the hydrogen. It's important to find out how much helium is present.

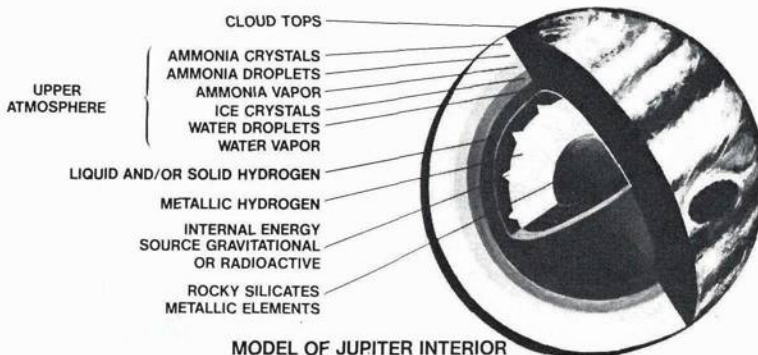
On Earth, the lightweight chemical elements of its original atmosphere were lost long ago. They evaporated away into space by a process called fractionation. Its present atmosphere originated later from the outgassing of the solid body of the earth. Munch explained that it's important to learn whether there has been any such fractionation on Jupiter.

Observations with the radiometer will start 2 hours 11 minutes before Pioneer reaches its nearest point to Jupiter and will end 83 minutes later. An actual temperature map will be built up that is capable of showing as much detail in the infrared as is seen in photographs taken with earthbased optical telescopes.

Temperatures measured near the edges of the planetary disk will be of higher levels of the atmosphere than those measured near the disk's center. That is because the infrared detectors have the ability to "look" into the atmosphere only to limited depths. It is similar to putting a stick in water; it can go deeper if it is put straight down than if it is inserted at a slant.

Because Jupiter is more than five times farther from the sun than is Earth, we have only seen that part of Jupiter that faces the sun. The radiometer of Pioneer 10 will provide the first look into the temperatures prevailing on the night side of the big planet. About two-fifths of the disk will be in shadow as Pioneer flies by.

"If Pioneer 10 survives the high energy particles in the vicinity of Jupiter," Munch added, "then Pioneer 11's course can be corrected so that it will swing by Saturn after flying by Jupiter, or its course may be changed to bring it closer to Jupiter than 100,000 miles. On the other hand, if Pioneer 10's electronics are damaged by the Jovian radiation, then Pioneer 11 can be directed to fly by Jupiter at a distance greater than 100,000 miles."



Scientific Opinion Divided About Life On Jupiter

Some scientists say there could be life on Jupiter; others say no. Even though scientists are divided on the subject, all agree a lot more study is needed before anyone can be sure.

Pioneer 10 will give man his first close-up look at Jupiter in December. But even the most optimistic scientist doesn't think Pioneer will find life.

Although the question of life beyond Earth has been pondered for only a few hundred of man's one million years, the last two decades have produced startling revelations. Stars surrounded by planets are now believed to be common and most scientists think conditions favorable to life also must be fairly common.

In addition to man's imperfect knowledge of other planets and other solar systems, he is hampered by relative ignorance about conditions under which life can exist. Life is not unduly fragile; indeed it seems incredibly tough.

For example, living organisms thrive in boiling hot springs and bacteria live in hot water inside nuclear reactors. Algae survive well enough in salt pools at 59 degrees below zero. Trees, buried and charred by lava from volcanic eruptions, soon put out new shoots and bloom again. Life is found even at the bottom of deep ocean trenches, under tons of pressure per square inch. The dry valleys of Antarctica were once considered the only sterile spots on Earth. They teem now with microorganisms carried there by visiting scientists.

In the 1950s, Dr. Stanley C. Miller and Prof. Harold C. Urey performed experiments at the University of Chicago that seemed to prove that life could occur spontaneously under the right conditions by chemical evolution. Miller and Urey combined methane, ammonia, water and hydrogen in a flask, then exposed the brew to electric discharges. They found some amino acids — the basic building blocks of life — had formed in their soup.

The atmosphere of Jupiter is known to contain methane, ammonia, and hydrogen — as well as, almost certainly, water, and helium. Add to that the relatively recent conclusions that the original atmosphere on Earth — when our home planet formed four billion years ago — was methane, ammonia, water, and hydrogen. These facts strengthen the arguments on the side of life.

On Earth, the first creatures apparently evolved by the application of energy lightning, solar ultra-violet — to the primordial atmosphere. Later, the process known as photosynthesis appeared, with organisms absorbing carbon and emitting oxygen. Gradually, as hydrogen was lost and oxygen built up, the atmosphere changed to its present composition.

Until recently, however, opponents of the life-on-Jupiter thesis had a powerful argument. The Jovian atmosphere was believed to be ice-locked in the near absolute zero chill of outer space. Solar energy radiation at Jupiter's distance from the sun (half a billion miles) is only 1/27 that at

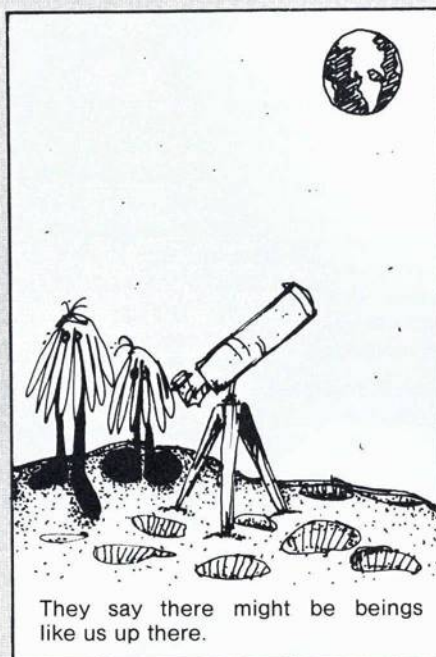
But that was sodium hydroxide. Those same organisms can't survive in high concentrations of ammonia — equally alkaline — that exist on Jupiter. But since they do survive in this earthly alkaline environment, perhaps similar organisms could survive the comparably alkaline ammonia concentrations of Jupiter.

Dr. Cyril Ponnamperuma of the University of Maryland has performed experiments that shed light on the Jovian environment and the possibility of life. While leading Ames Research Center's Chemical Evolution Laboratory, Ponnamperuma mixed a chemical soup identical to Jupiter's atmosphere, and exposed it to electric discharge, much like the Miller-Urey experiments. Ponnamperuma's studies indicate that Jupiter's Great Red Spot could be a giant cauldron, brewing the precursor elements of life.

Contrary evidence has been spelled out by Dr. Gerard P. Kuiper of the University of Arizona's Lunar and Planetary Laboratory. Dr. Kuiper says the Jovian Red Spot's color is caused by chains of inorganic (non-living) chemical compounds. Dr. Kuiper has spent his long career studying the planets in great detail and believes wholeheartedly that, "while there may be some chance of finding life on Mars, it is a chemical impossibility on Jupiter."

As with any major question, the question of life on Jupiter must await further evidence from spacecraft. Some future projects include Jupiter orbiters and atmospheric entry probes. Most would use Pioneer spacecraft similar to the one now nearing the mighty planet.

Pioneer 10 will fly within 81,000 miles of Jupiter's cloud tops on Dec. 3. Pioneer 11, a near twin, will arrive at Jupiter a year later on Dec. 5, 1974.



Earth's distance. But Jupiter was then discovered to have its own internal heat source (see companion article — "Jupiter to Have Its Temperature Taken") and almost certainly vast regions of room temperature atmosphere favorable to some form of life.

Another argument against life was the extreme alkalinity of Jupiter's environment. Many believed nothing could survive. Then two scientists at NASA's Ames Research Center found unnamed bacteria living — swimming, growing, and reproducing — in a highly alkaline solution of sodium hydroxide. Biologists Paul Deal and Kenneth A. Souza found the organisms in an alkaline spring in northern California.

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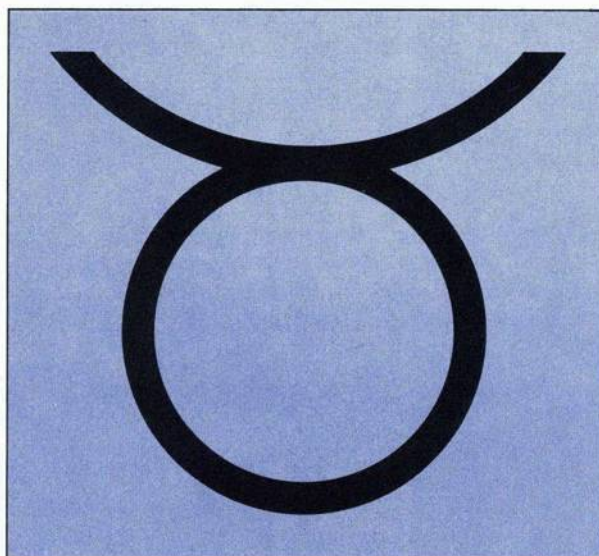
NASA Photograph



CONSTELLATION CLOSE-UP

Taurus

by
Thomas C. Bretl



**"Many a night I saw the Pleiades, rising
thro' the mellow shade,
Glitter like a swarm of fire-flies tangled
in a silver braid."**

Tennyson

There is a timeless, eternal quality to the heavens. Although stars are born, die, and exhibit proper motion, most stellar change comes very slowly, and the sky we see tonight is much the same as the skies of all our ancestors. The Pleiades hang low in the east on early December evenings as they have for thousands of years — the seven daughters of Atlas to the Greeks, a "swarm of

fire-flies" to Tennyson, and the heart of Taurus, a harbinger of brilliant winter constellations, to the amateur astronomer today.

Because Taurus consists primarily of the Pleiades and another very large open cluster, the Hyades, it enjoys a permanence even beyond that of other constellations. While most of the stellar patterns we trace in the sky are accidents of perspective, destined to slow, but steady, change

TABLE OF OBJECTS IN TAURUS

Double Stars

Star	Magnitudes	Sep.	Colors	R.A.	Dec.
α	1.1-11.2	121"	Orange-gold	04 ^h 34 ^m	+16°27'
Σ 422	6.0- 8.2	6.0"	Gold-blue	03 ^h 35 ^m	+00°30'
30	5.0- 9.3	9.2"	Green-purple	03 ^h 47 ^m	+11°03'
Φ	5.0- 8.7	52.1"	Red-blue	04 ^h 19 ^m	+27°16'

Open Clusters

NGC	Herschel	Magnitude	Size	No. of Stars	R.A.	Dec.
Mel 22	(Pleiades)		100'	130	03 ^h 45 ^m	+24°02'
Mel 25	(Hyades)		330'	40	04 ^h 18 ^m	+15°34'
1647	HVIII-8	8.5-10			04 ^h 44 ^m	+19°01'
1758	HVII-21				05 ^h 03 ^m	+23°44'
1817	HVII-4	9	15'	10	05 ^h 10 ^m	+16°40'

Planetary Nebulae

NGC	Magnitude	Size	Central Star Mag.	R.A.	Dec.
1514	11	2'x1.5'	10	04 ^h 07 ^m	+30°41'
1952(M-1)	8	6'x4'	16	05 ^h 33 ^m	+22°00'

EPOCH 1970

with the passage of time, the members of each of these two clusters show parallel proper motions, thus retaining their cluster shapes as they each move in separate units relative to the rest of the stars.

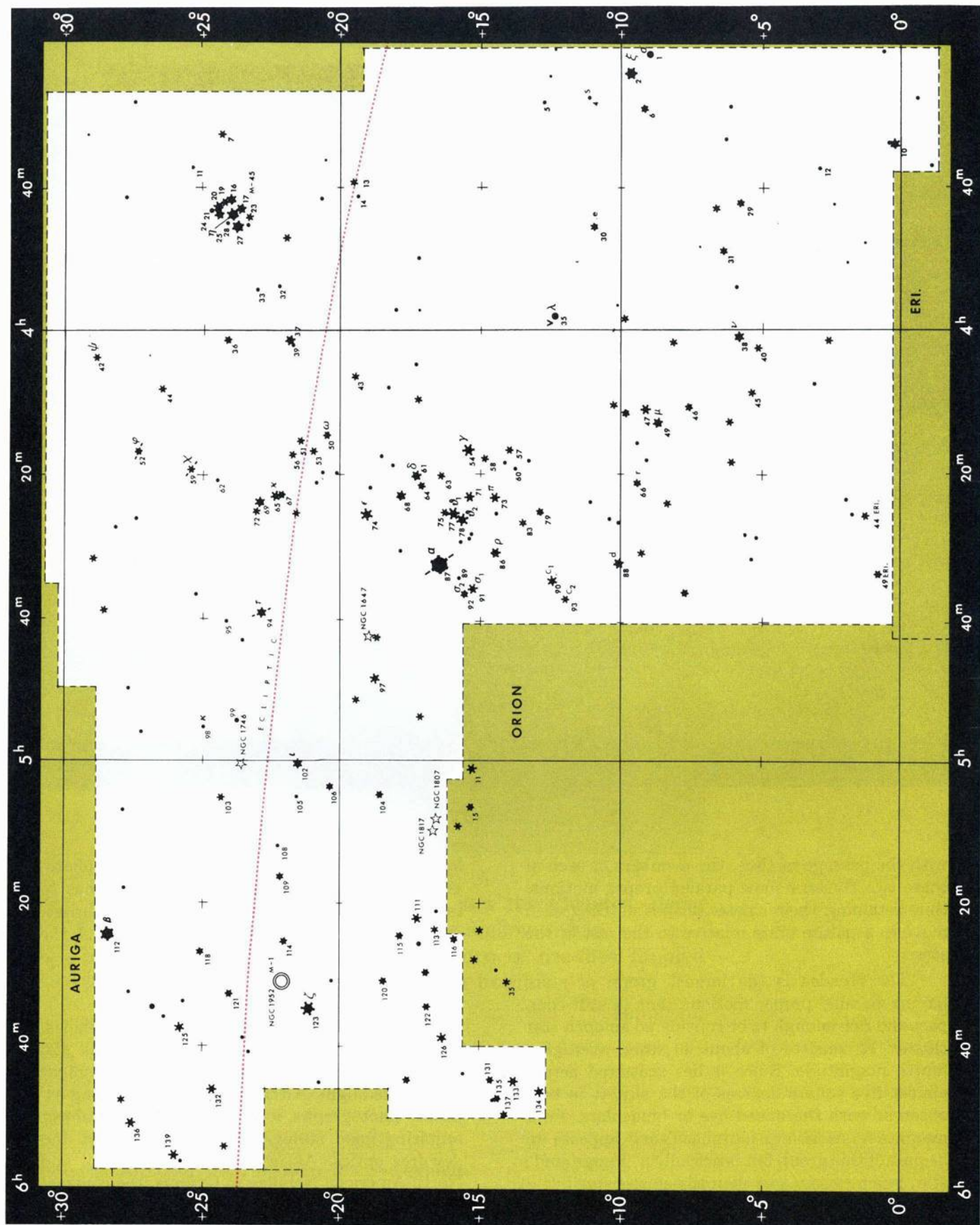
The Hyades is the largest group of stars having parallel proper motions that is still compact and rich enough to be considered an open star cluster. It consists of about 40 stars, averaging fourth magnitude. Since it lies scattered across almost five square degrees of the sky, it is best observed with the naked eye or binoculars. First magnitude Aldebaran (Alpha Tauri) appears to be part of this group but is actually a "foreground" star, much closer to us than the cluster itself.

Aldebaran means "the follower", and it is the Pleiades that it follows across the sky. This tiny "dipper" configuration of stars is undoubtedly the best known of all open clusters. Six stars are visible to the average naked eye observer, but over 100 can be seen in a small telescope and at

least 250 are recorded in long exposure photographs. A low power view of this cluster has to rank near the top of everyone's list of favorites. It is especially striking not only because of the number and brightness of its members, but also because of their identical blue-white color, characteristic of such hot, type B stars.

Enveloping the brightest stars in the Pleiades, particularly Merope (23 Tauri) and Maia (20 Tauri), is a faint diffuse nebulosity which shines by reflected light. Although prominent in long exposure photographs, it is an elusive visual object requiring good seeing conditions, and dust and dew-free optics. As in the case of the Veil and North American Nebulae in Cygnus, the contrast provided by a wide field of view is important, and a larger telescope, with its accompanying higher magnification, does not usually help. A richest field telescope can be used here to best advantage.

Taurus is truly a constellation of open clus-



Stellar Magnitudes -1 0 1 1.5 2 2.5 3 3.5 4 4.5 5 5.5 6 & fainter

Diffuse Nebula Double Stars Variable Stars

Galaxies

Planetary Nebula

Open Star Clusters

Globular Clusters



ters, for in addition to the Pleiades and Hyades three other interesting groups can be found not far from Aldebaran. The Herschel classification given in this month's table of objects gives you some idea of their structure. A classification of VII is given to compressed clusters of small and large stars, while a classification of VIII is given to coarsely scattered clusters of stars. The accuracy of these classifications, however, depends somewhat on the aperture of the telescope used, and may prove misleading in the case of HVII-21 which, in photographs, looks larger and coarser than either HVII-4 or HVIII-8.

Not all the noteworthy objects in Taurus possess the same quality of permanence that belongs to the open clusters. The Crab Nebula, for example, is the result of a quite sudden stellar change in 1054 A.D. In that year a supernova was observed where M-1 is now located, and the planetary nebula we see today is believed to consist of the still rapidly expanding remnant gases of that exploded star. The eighth magnitude Crab is easily found in small telescopes, one degree northwest of Zeta Tauri. Little of the detail seen in photographs is visible, and the central star, once a spectacular nova, has now faded to a very inconspicuous 16th magnitude.

Other Taurid attractions of a more unpredict-

table or impermanent nature include an annual meteor shower and the variable star Lambda Tauri. The shower, associated with Comet Encke (1953f), occurs during the last week of October and first two weeks of November. Its radiant is at right ascension 3 hours 32 minutes, declination 14 degrees, and a peak rate of about 15 meteors per hour can be anticipated.

While the meteors appear with an unpredictable randomness that tries the observer's patience, variables like Lambda exhibit a very predictable and regular change. It is an eclipsing variable similar to Algol in Perseus, and its magnitude fluctuates between 3.5 and 4.0 over a period of just slightly less than four days. Lambda is easy to find. It is bright enough, of course, to be easily seen with the naked eye, and the V-shaped Hyades point directly toward it, five degrees to the southwest.

A glance at this month's table of objects shows that Taurus has something to offer every observer, whether he owns a large or small telescope, binoculars, or no optical aid at all. Whether you wish to pause to reflect on the seeming immortality of the stars, compared to man's lifetime, or stop to imagine the cataclysmic events that can and do occur within them, Taurus is a good place to turn to spend a starlit December night. ☛

ANNOUNCING

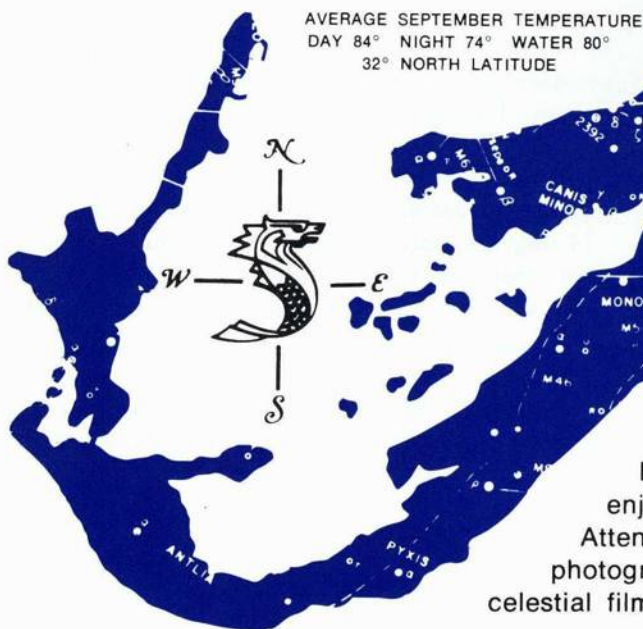
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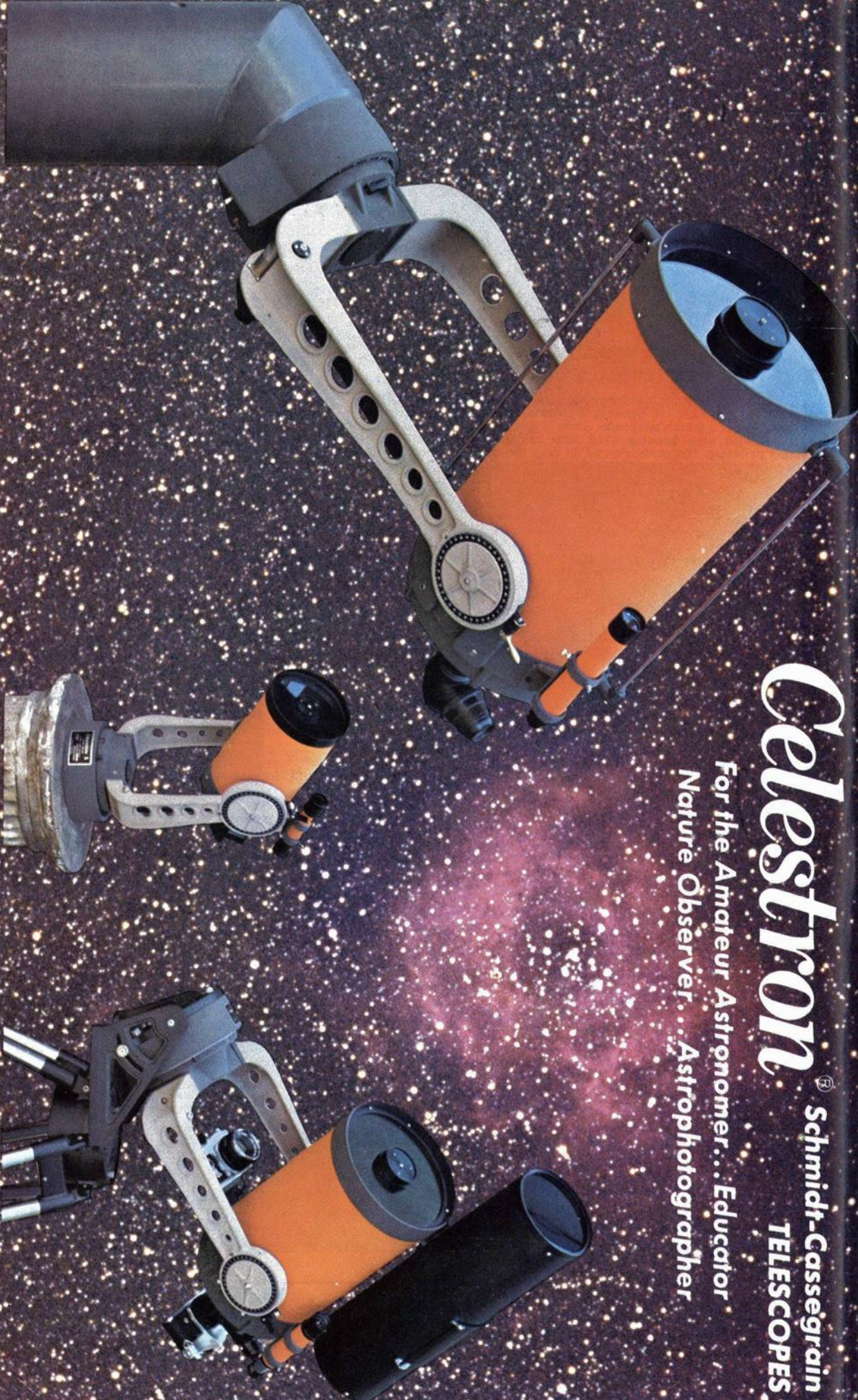
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Background Photo — The Rosette Nebula, Celestron 5½-in. Schmidt Camera

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